



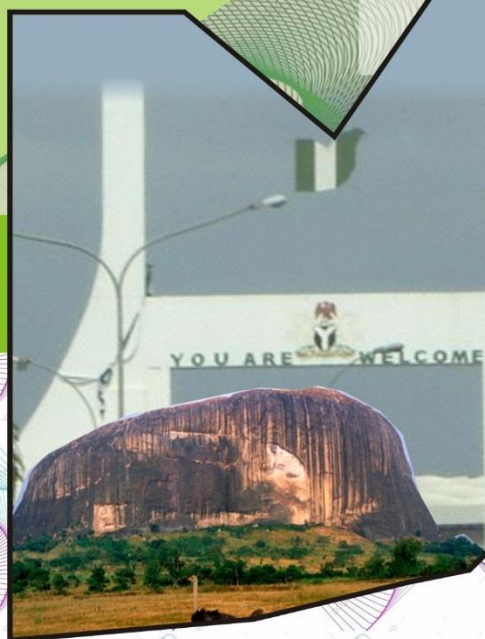
NIGERIAN INSTITUTE OF FOOD SCIENCE AND TECHNOLOGY

(INCORPORATED IN NIGERIA RC 247011)

PROCEEDINGS OF THE

46th

Conference & Annual General Meeting



Theme

**"ADVANCING NATIONAL DEVELOPMENT,
WEALTH CREATION, AND FOOD SECURITY THROUGH FOOD
PROCESSING AND PRESERVATION"**

Date:

17 - 21st October 2022

Venue:

National Center for Women Development,
Opp. Central Bank of Nigeria (CBN),
Tafawa Balewa Way, Central Business District, Abuja

Time:

10:00am





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The Nigerian Institute of Food Science and Technology

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GENERAL INFORMATION ON NIFST

NIGERIAN INSTITUTE OF FOOD SCIENCE AND TECHNOLOGY

The Nigerian Institute of Food Science and Technology (**NIFST**) is a registered Non-Profit Making Body representing Food Professionals drawn from the Academia, Industry, Government and Research organisations in Nigeria. The Mission of the Institute is a reflection of the rich Human Resources of NIFST.

Established in 1976, **NIFST** membership has grown to well over 15,000 with eleven active chapters spread across all the geopolitical zones in Nigeria. NIFST membership also extends beyond the shores of Nigeria with members resident in the United States, United Kingdom, Canada, South Africa, Ghana etc.

The Profession of Food Science & Technology in Nigeria became chartered with the establishment of the Nigerian Council of Food Science & Technology (NCFST) Act Cap A2 LFN of 16th October 2019 signed into law by the President and Commander in chief of the armed forces of the Federal Republic of Nigeria, President Muhammadu Buhari.

NIFST provides professional support to individuals, public & private institutions and the food industry, advances and promotes Food Science and Technology as a Profession cum Discipline which contributes to Nation building. Over forty Institutions of higher learning in Nigeria offer this discipline.

The National Secretariat of **NIFST** is situated in Lagos State of Nigeria. This secretariat also hosts the Secretariat of the West African Association of Food Scientists and Technologists, **WAAFoST**. **WAAFoST** is the regional affiliate of the International Union of Food Science and Technology (**IUFoST**).

Our Institute actively supports sustainable economic development of Nigeria, through development of its human capital resource and creation of a sound economic platform, particularly in the Food & Allied Industry. These programmes are achieved through such activities as inventions and innovations, Consultancy, Symposia, Seminars, Training Workshops, Lecture Series and Career Talks organized either solely or in partnership with other Government Agencies, Research Institutes or Professional Bodies.

Through the teachings and practice of Food Science and Technology, **NIFST** has contributed tremendously to the phenomenal interest in the study of Food Science and Technology as a course and the growth of the Food Industry in Nigeria. **NIFST** believes in partnerships through collaborations, consultations and cooperation and has signed a number of MOUs and intends to do more with public and private organizations to optimize its objective of adding value to the food business and knowledge.

To date, **NIFST** has organized 46 Annual General Meetings (**AGM**) & Conferences where members converge to brainstorm, discuss/proffer suggestions on thought-provoking issues related to the Profession, Food Processing and Food Security.

Another area of focus, by **NIFST**, is the biannual publication of the Nigerian Food Journal (**NIFOJ**). The Food Journal was first published in 1983 and has remained an annual publication of the Institute to date.

The **NIFOJ** is rated among the top 3 scientific journals by the Elsevier Publishers, a leading publisher of scientific journals, in 2014. The publishing company also hosts the **NIFOJ** on its site. From inception to date, it continues to serve as Nigeria's only organ of information dissemination on current Food/ Food Related Research Findings.

Other publications, from the Institute, include:

- a) Academic brochures such as Proceedings of Conferences and Symposia, Seminar, Book of Abstracts of Research Findings
- b) Information brochures such as Monthly Newsletter and Quarterly Magazine - THE FOOD FORUM MAGAZINE- packaged to serve the Food Industry and the General Public at grass root level.

NIFST has achieved more than the critical minimum of Scientific and Technological know-how required for the successful provision of Wholesome Foods for Nigerians. The Institute also promote job creation, wealth generation and poverty alleviation through advanced training workshops to educate, encourage and empower Micro-, Small- and Medium- Scale Entrepreneurs.

GOVERNANCE

A Board of Trustees and Governing Council pilot the affairs of the Institute. The Governing Council is made up of Principal Officers elected at **AGM**, Chapter Chairmen and Committee Chairmen constituted for specific assignments. The Corporate Affairs, Scientific & Training and Student Affairs Committees are coordinated by the 1st Vice President, 2nd Vice President and Assistant National Secretary respectively.

Members

The categories or type of membership (I) Student member; (ii) Associate member (iii) Licentiate member; (iv) Professional member; (v) Honorary Member; (vi) Fellow (vii) Honorary Fellow (viii) Corporate member.

The requirements for admission to the above categories or grades of membership shall be as follows:-

- (i) **Student Member:** He shall be a person not under 16 years of age, enrolled in a recognized course of study in Food Science or Food Technology at the time of application, and shall satisfy the conditions laid down by the Governing Council.
- (ii) **Associate Member-** Individuals with B.Sc. in allied courses such as Nutrition, Biochemistry, Industrial Chemistry, Microbiology, etc shall be admitted as Associate members. An individual so admitted as Associate member shall remain so until upgraded to Licentiate member when and if such an individual acquires a PGD in Food Science and Technology and subsequently to professional member when and if he/she acquires a master's degree in Food Science and Technology.

(iii) Licentiate: He shall be a person who has either

- (a) Individuals with ND and 2years post qualification shall be admitted as Licentiatees**
- (b) Graduates from other related fields of study with relevant experience in food science and technology (or food processing)
- (c) Satisfied the Council requirements by virtue of his experience in the field of Food Science and Technology and in view of the responsibility of his employment and by any additional evidence acceptable to the Council, that he is a suitable person to be admitted.

(iv) Professional Member: He shall be a person who has either

- (a) HND or B.Sc. or B.Tech. Degree in Food Science and Technology or Food Science or Food Technology.

OR

- (b) OND in Food Science and Technology or Food Science or Food Technology who must have been admitted into Licentiate membership for at least one year and has applied for membership upgrade provided he/she has a minimum 5 years relevant experience in a unit/department of an organization/institution in which scientific post-harvest food issues/business are processed/regulated/taught/researched as regular work.

OR

- (c) Any of HND or B.Sc. or B.Tech. or B. Eng. in Nutrition, Brewing Science and Technology, Food Engineering, Food Science and Microbiology, Chemistry, Industrial/Applied Chemistry, Chemical Engineering, Science Laboratory Technology, Biochemistry, Microbiology, Industrial/Applied Microbiology, Biotechnology, Agric. Engineering, Mechanical Engineering and Medicine who must have been admitted into Licentiate membership for at least one year and has applied for membership upgrade provided he/she has a minimum 5 years relevant experience in a unit/department of an organization/institution in which scientific post-harvest food issues/business are processed/regulated/taught/researched as regular work.

OR

A Post Graduate Diploma (PGD) in Food Science and Technology **plus** HND or B.Sc. or B.Tech. or B. Eng. or in Food Science and Nutrition, Brewing Science and Technology, Food Engineering, Food Science and Microbiology, Chemistry, Industrial/Applied Chemistry, Nutrition, Chemical Engineering, Biochemistry, Microbiology, Industrial/Applied Microbiology, Animal Science, Agric. Engineering, Mechanical Engineering, Science Laboratory Technology, etc.

- (v) **Honorary Member:** He shall be a person who has HND or B.Sc degrees plus 5 years (minimum) of association with food production & the Institute.
- (vi) **Fellow:** He shall be a person not under 35 years of age who has fifteen years of NIFST membership with substantial evidence of contribution and active participation. Such interested member would apply to the Council stating biodata/qualification.
- (vii) **Honorary Fellow:** The title may be conferred by the Institute on an individual with more than 20 years of association with the food industry and the institute or an outstanding national of immense benefit in the Food Industry or to the Institute.
- (viii) **Corporate Member:** This shall comprise Companies dealing with food production, packaging, distribution and sales in Nigeria.

Our Vision

GOOD AND ABUNDANT FOOD FOR ALL THROUGH SERVICE TO HUMANITY AND COUNTRY, RESULTING IN FOOD SECURITY AND THE WELLBEING OF NIGERIANS

Our Mission

TO HARNESS THE ABUNDANCE OF TALENT, KNOWLEDGE AND SKILLS AMONGST FOOD PROFESSIONALS IN NIGERIA, TOWARDS FOOD SUFFICIENCY AND GOOD NUTRITION OF THE MASSES

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EDITORIAL COMMENT

My beloved NIFSTers! The 46th National Conference and Annual General Meeting of the Nigerian Institute of Food Science and Technology (NIFST) unfolds with the theme “Advancing National Development, wealth Creation and Food Security through food processing and preservation” despite numerous challenges encountered in the course of the year. This theme could not have been more relevant than now when the country is faced with security challenges that



could affect food production by farmers. If less food is produced certainly it is going to affect the food security of the Country. On the other hand, food crops are raw materials for agro food processing industries which if not made available will affect the output of the companies, thereby affecting their income. If the income of agro-processing industries declines, it will lead to retrenchment of workers, hence poverty will set in and standard of living declines. This will affect national development. Therefore, it was necessary for NIFST Governing Council to project “Advancing National Development, wealth Creation and Food Security through food processing and preservation “for deliberation at the 46th anniversary of our great professional body, NIFST, in the Federal Capital Territory (FCT) Abuja - the Centre of Unity.

The Editorial Subcommittee members are grateful to NIFST Governing Council for the mandate to produce this E-Proceedings. We are equally grateful to the diverse experts who contributed their research breakthroughs, technologies and innovations, without which our mandate would have been impossible to accomplish. However, it is worthy to note that despite the Academic Staff Union of University (ASUU) strike and other challenges, we recorded significantly increased number of submitted Manuscript; whereas we had over 174 abstracts by the end of August, 2021, we received over 180 manuscripts by end of September, 2022.

Furthermore, NIFST at its 196th Session of the Governing Council meeting held on Saturday 12th February 2022 decided to shift from publication of extended abstracts to full five page paper publication in conference book of proceedings and therefore it was a herculean task to handle these manuscripts by members of the sub-committee editorial board. The accepted manuscripts were classified according to specific areas in Food Science and Technology discipline, for enhanced value to members during presentation at the three parallel Technical sessions.

I wish to commend the Publication Officer - for his devotion and commitment. My profound gratitude goes to the Editorial Sub-committee members (Chinma, C. E., Danbaba, N., Yakubu, C. M., James, S., Ajenifujah-Solebo, T., Adedeji, O. E., Balogu, V. T. and Okafor, G. I.) and NIFST Secretariat staff, for their collective efforts which facilitated the successful execution of this task. Finally, I appreciate the Council members and entire NIFST family for the reposed trust and the opportunity to serve.

Professor M. H. Badau, MNIFST
Chairman, Editorial Sub-Committee
Deputy Editor-in-Chief, Nigerian Food Journal

**AN ADDRESS BY THE PRESIDENT,
NIGERIAN INSTITUTE OF FOOD SCIENCE
AND TECHNOLOGY (NIFST), PROF
MADUEBIBISI OFO IWE, CFS, TO THE
46TH ANNUAL CONFERENCE AND
GENERAL MEETINGS FROM 17TH TO
21ST OCTOBER 2022**

Protocol

It is a great privilege and honor for me to welcome our invited guests and attendees to the 46th NIFST Conference and Annual General Meeting (AGM) of our great Institute with the theme **"ADVANCING NATIONAL DEVELOPMENT, WEALTH CREATION, AND FOOD SECURITY THROUGH FOOD PROCESSING AND PRESERVATION"**. I am pleased to address the conference here in Abuja the capital territory because this shall be my second and last address to you as the President of the Institute, having successfully led in the management of the Institute in the last two trying years. The last two years have experienced terrible uncertainties fueled by the COVID-19 pandemic, widespread insecurity, banditry, operations of BOKO-HARAM, deep economic crisis, nation-wide university staff-union industrial actions, etc. All these have seriously contributed to poor turn out in our chapter and national programs. However, we have carried on with deep-seated commitment and faith for which this conference has become a reality.



Let me then appreciate the Almighty God for yet another opportunity for us to meet at this level of our profession. This is usually a special moment for the Food Science and Technology family in Nigeria, the largest congregation of the food professionals in Africa, to meet and rub minds on food and nutrition research because it offers us the opportunity to discuss the management of the business of our Institute and to review the direction of research and development over a given period.

The theme of our 2022 Conference, Advancing National Development, Wealth Creation, and Food Security through Food Processing and Preservation is apt. The Nigerian government and the Nigerian consumers are desirous of seeing breakthroughs in the local Nigerian food industries. They want to see the industry provide enough food for her teeming population, save foreign exchange through lowering of importation of goods which has become a nemesis in the Nigerian economy and create wealth for all Nigerians. There is the need for us to broker these expectations and address the much-harped

importation of foreign food stuff and processed products so that they give way to our local food manufacture and consumption.

Food processing is the transformation of agricultural products into food, or of one form of food into other forms. Food processing includes many forms of processing foods, from grinding grain to make raw flour to home cooking to complex industrial methods used to make convenience foods. It offers important benefits to businesses and consumers, including a more varied food supply and foods with a longer shelf life. Certain aspects of food processing, however, raise concerns over dietary health, worker health, and food safety.

However, processing makes food more edible, palatable, and safe, and preserves it so it can be eaten beyond the harvest season. Food processing is also a tool that offers greater variety in foods and therefore increases the consumer's choice. It boosts the shelf life of food products, prevents food-contamination; enhances food storage and transportation; turns raw food materials into attractive, marketable products, and provides employment to a large population.

Threats to global food security present a challenge that most people agree is only getting worse. The possibility of achieving a food secure world without sustainable development is highly debated in policy and academia. A recently published article in the journal of Public Health Nutrition explores this notion along with the evolution of food security from the 1970s to present day. In an analysis of more than 80 articles, the authors posit that one cannot exist without the other. This conclusion sheds light on previously unidentified challenges to food security, such as rural transportation, infrastructure, and even our diets.

The concept of food security has grown over time. In the 1970s the focus was solely on supply due to the extreme instability of agricultural commodity prices. Over time, it expanded to include food access and nutrition, embracing the critical needs of vulnerable populations. By 2001, the definition of food security had adopted nutrition and evolved to its most present definition: a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food and nutrition security is the realization of everyone's right to regular and permanent access to quality food in sufficient quantity without compromising access to other essential needs, based on best practice health promoting food that respects cultural diversity and that are environmentally and economically compliant. Food Security and Sustainability is imperative to feed the growing population and minimize the effects of climate change. How food is grown and produced, what types of foods are consumed and how much food is wasted have major impacts on the sustainability of the world's food system. The United Nations estimated that the world's population will reach 9.7 billion by 2050. Food Security

and Sustainability is imperative to feed the growing population and minimize the effects of climate change.

Consumers' sustainable food consumption reduces the risk of unsustainable agriculture, which is associated with unsustainable consumption and agricultural practices and environmental degradation.

Food processing enhances the shelf life of food through various ways such as microorganism control, low-temperature storage, dehydration, and removal of oxygen. It also alters the texture, flavour, and nutritional value of food products to appeal to consumers.

Food preservation stops the growth of microorganisms (such as yeasts) or other microorganisms (although some methods work by presenting benign bacteria or fungi into the food), and slows the oxidation of rancid-causing fats. Food preservation gives the food more variety.

The scope and importance of food processing are vast, with many different methods used to achieve different results. Food can be processed and preserved in many ways, including canning, freezing, dehydration, pickling, and irradiation. The most common method of food processing is probably cooking, which prepares food for consumption in various ways. Cooking can be done at home or in a commercial setting, such as a restaurant or factory. Generally, food processing and preservation can be defined as all the activities and operations required for converting raw agricultural produce into safe and nutritious food products. Food processing and preservation are necessary to ensure access to safe, wholesome, and palatable foods at reasonable costs.

Food processing industry accounts for about 10% of India's GDP and employs around 15 million people. The sector is multiplying and is estimated to reach a value of Rs. 2,58,000 by 2022. There are many opportunities for investment in the food processing sector, and it offers good returns on investment.

The food processing industry has a crucial role to play in the development of India's economy. The sector is integrating the country's strategy for inclusive growth by creating an enabling environment that encourages investments in infrastructure, research, innovation, and technology upgrade. This is the way to go in our own situation. The food industry in Nigeria is not contributing significantly to national development due to the low involvement of food professionals in it. It has become an all-comer affair, and that is why NIFST has done what it ought to do by pursuing and securing a charter for the practice of the profession of Food Science and Technology in Nigeria. NIFST remains grateful to the President of Nigeria for signing the charter into law in October 2019, for which we now have the Nigerian Council for Food Science and Technology (NiCFoST).

To meet the current demand of food materials, the industrial food processing sector has emerged. The food processing sector in this country as earlier stated is mainly handled by the unorganized sectors. It is estimated that 42% of the output comes from the unorganized sector, 25% comes from the organized sector and the rest of it comes from the small-scale players. The small-scale food processing sector is a major source of employment and adds value to crops by processing. It is a major source of food in the human diet.

The small-scale food processing sector is, however, under increasing threat and competition from the large manufacturers through economies of scale and better presentation and marketing. Good packaging lies at the very heart of presentation and thus customer appeal. It is an area of vital importance for small and medium food manufacturers if they are going to continue to compete and expand. With food processing, it is possible to maintain nutritious and safe food supply for the millions of people that inhabit both urban and rural areas. Improvement in processing efficiency, by increased yield of usable product, is a tangible means of reducing food loss and increasing food supply. Demand for increased convenience of food preparation in the home, institution and restaurant has created a need from processing industries for food ingredients as well as new food forms. There are many promising dynamics that support good growth of the food industry. There are still some significant constraints which, if not addressed properly, can impede the growth prospects of the Food Processing Industry. One of the biggest constraints is that this industry is capital intensive. It creates a strong entry barrier and allows lesser number of players to enter the market. Lesser players mean lesser competition and lesser competition means reduced efforts to improve the quality standards. There are other two constraints which pertain to maintaining the standards of quality. The first among them is poor infrastructure for storing raw food materials. Two main types of storages – the warehouses and the cold storages, lag in storage standards. Pests infest the grains sometimes due to lack of monitoring, proper use of pesticides and proper ventilation. Similarly, power outages result in sub-optimal function of the cold-storages and the quality of food material in the cold storages becomes questionable. The second important aspect is having poor quality standards and control methods for implementing the quality standards for processing and packaging processed foods. This is where we see NiCFoST coming in to help upgrade standards of our industry whenever it starts to regulate the practice of personnel in institutions and industries involved in food handling, distribution and consumption. To this end, we use this opportunity to appeal to the Hon Minister of Science, Technology and Innovation to fast-track the inauguration of the Council (NiCFoST) in the interest of a more productive Nigeria food industry.

In addition, continuity of quality power, good quality water for processing, instruments for rapid and reliable analysis, versatile instruments/equipments for multi commodity, and cultivars are concerns for specific processing, in the food processing industry.

Unless these important constraints are addressed it will be difficult to break the cultural barrier where people prefer fresh food over packaged food. It will be difficult to gain customer confidence and the perceived growth of this industry may not be so lucrative.

Nigeria was one of the world's most promising agricultural producers soon after her independence sixty-two years ago. Regionally focused policies based on the economic principle of commodity comparative advantage ensured that the agricultural sector served as the nation's main source of food and livelihoods. Nigeria was not only agriculturally self-sufficient and food secure, but it thrived in global markets as the world's largest producer of groundnuts and palm oil and as a significant producer of cotton and cocoa."

Problems of agriculture in Nigeria that have eroded the scenario have been pin-pointed at one or the other to include oil discovery in commercial quantity and subsequent over-reliance on the accruable revenue; lack of supporting basic infrastructure for mass crop production such as dams and irrigation facilities; poor means of land preparation; and storage and processing facilities are still in short supply.

Other challenges include poor yield per hectare in all the arable and cash crops; inadequate financing systems; poor industrialisation of raw agricultural products; difficult business operation environment and grossly epileptic power supply.

Prominent among what experts suggest should be done are research and development of improved farm inputs; government and private investment momentum in land preparation technologies and equipment; production and processing technologies; and post-harvest management technologies, all supported with a robust and low-interest financing systems. Development of improved seedlings, seed varieties to tackle the poor yield per hectare phenomenon, unsustainability, and low income accruable to food cultivation improved, early-maturing, high-yielding and pest/disease tolerant inputs of seeds, seedlings and other planting materials are essential, which, in turn, will help the economy sustainably.

A few research efforts to do these have resulted in some registered, approved and released varieties of crops and animal strains by the National Variety Release Committee of the Federal Ministry of Agriculture. Local and international institutes/organizations which have developed improved varieties include, among others, AfricaRice Centre, Ibadan (NERICA 8 & 9, FARO 44), which has helped in increasing paddy production from an average of two tonnes per hectare to about six; and the International Institute of Tropical Agriculture (IITA) (vitamin-A bio-fortified cassava, improved cassava varieties TM419, potato and maize). Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Edo State has come up with some early-maturing palm and coconut varieties. The Institute of Agricultural Research and Training (IAR&T), Ibadan and the Institute of Agricultural Research (IAR), Zaria have bred early maturing and drought-tolerant cereals, grains, and pulses. The Cocoa Research Institute of Nigeria (CRIN) and the Forestry Research Institute

of Nigeria (FRIN), Ibadan, respectively have developed early maturing cocoa, cashew, and bitter kola; and the Nigerian Horticultural Research Institute (NIHORT), has bred improved horticultural products, fruits, and vegetables seeds/seedlings.

Unfortunately, adoption and up-scaling of these varieties are negatively influenced by a collapsed extension system, reluctant and scanty investments into research, extension and further research on industrialisation of crops, as well as poor agricultural financing, power supply, erratic increases in prices of fuel and unpredictable economy.

Appropriate national development and wealth creation are indicators of a healthy nation. It is getting worrisome that these indicators are not being properly handled by the people of Nigeria, especially with respect to the food industry. The food industry requires all the necessary agricultural, power and even basic good-will by all and sundry to survive and make the expected impacts. NIFST as a professional body has the capacity to make rightful contributions by ensuring sustained effort in engineering and re-engineering food production, processing, and preservation in Nigeria. If optimization of natural and human resources is the way to go, NIFST is ready to lead the fight to ensure future and hope for our already distressed society.

We are here today to celebrate our 46th anniversary of this great professional body. We have gone a long way in coming this far. Attaining this age at a time the entire world is upset with hunger, malnutrition, trade deficits, and all manner of helical food related problems calls for more concerted effort from the Institute, allied professional bodies, government, and people of Nigeria to team up to address the worrisome issue. We have a serious responsibility to rise to the occasion and make serious and immediate impact on the matter. We are making this call here at the Federal capital of Nigeria within a period of campaigns for the election of new leaders in Nigeria. It is very important that our upcoming leaders take the matter of national development, food security, and wealth creation in relation to food production, processing and preservation seriously. We must take time to make justifiable contributions to this contemporary global question of what our roles should be on Food Security, national development and wealth generation through the Nigerian food industry.

As I conclude this address, let me appeal to all NIFSTers, and participants to make good use of the opportunity offered by this event to share knowledge and discuss exhaustively on the theme to enable us offer practical solutions to the teething problems facing the Nigerian food industry.

On behalf of the Council and entire membership of the Institute, I offer my profound gratitude to the Hon Minister of Science and Technology for his continuing fatherly role in strengthening the Institute and the Council; Hon Minister of the Federal Capital Territory

to accommodating us in the city of Abuja and making the environment suitable for our conference. We acknowledge the contributions of Dr. OgbonnayaOnu, former Hon Minister of Science, Technology, and Innovation for the wonderful role he played for indirectly giving NIFST a sense of belonging through giving care to the young baby NiCFoST. We thank Prof S.E. Bogoro for his commitment to the cause of NIFST, especially as a former Executive Secretary of TETFund. I congratulate our new fellows and inductees, for rising to the top of our profession. I wish to also extend our profound gratitude to all our sponsors for all the provisions they made to enable us hold this conference; our pathfinders for always being there for us; Abuja chapter and members of the LOC for accepting the responsibility to host and provide everything possible for the conference. and for all NIFSTers for making it to Abujaamid all odds.

Long live NIFST!

Long live the Federal Republic of Nigeria!!

Prof Madu O. Iwe, FNIFST, CFS

President NIFST&Vice-Chancellor Michael Okpara University of Agriculture, Umudike.

TEMPLATE FOR SUBMISSION OF MANUSCRIPT FOR THE 47TH NIFST CONFERENCE AND AGM

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Abstract (This must not be more than 200 words written in Garamond font 11, single spacing)

The impact of germination alone or in combination with solid-state fermentation on the physicochemical, antioxidant, in vitro digestibility, functional, and thermal characteristics of brown finger millet were evaluated. Germination and fermentation increased ($p \leq 0.05$) the protein, crude fiber, minerals, resistant starch (7.64-9.69 g/100g), total flavonoid content, total phenolic content, antioxidant properties (ABTS, DPPH and FRAP), majority of the amino acids as well as in vitro protein digestibility (67.72-89.53 %), while antinutritional factors and digestible starch (45.17-35.58 g/100g) content decreased significantly. Germination and fermentation significantly increased water absorption capacity and protein solubility, and slightly modified the pasting and thermal characteristics of brown finger millet flour while bulk density decreased. Among the treatments, combined germination and fermentation greatly improved the physicochemical, antioxidant, functional and processing properties of the flour with reduced antinutrients. Such combined process could enhance the use of brown finger millet as a novel flour in food product development.

Keywords (Not more than 5 keywords, first letter capitalized): Nutritional, Antioxidant; Germination, Solid-state fermentation, Finger millet.

1.0 Introduction (This should be written in Garamond font 11 with single spacing)

Finger millet (FM) is an underutilized whole grain cereal majorly grown in sub-Saharan Africa especially in Nigeria, and reported to have nutritional, nutraceutical and low-glycemic index advantages, but remains underutilized (Adebisi *et al.*, 2018). Finger millet is rich in essential amino acids such as histidine, lysine, methionine, tryptophan and also a good source of vitamins (Jideani, 2012). However, the availability of these nutrients is limited by the presence of antinutritional factors (ANFs) especially tannins, phytic acid and oxalates inherent in the grains. Several processing techniques (such as roasting, soaking, cooking, germination fermentation), amongst others have been used to improve nutrient availability and subsequent

products such as flour and starch from the grains have been used in the preparation of stiff porridge, weaning food, baked products and in pharmaceutical industries (Verma & Patel, 2013).

The primary objective of germination is to promote activation of inherent hydrolytic enzymes initially dormant in the raw seed (Ayernor and Ocloo, 2007) and has been known to improve nutritional value, cause structural modification, reduce ANFs, soften the kernel structure, and improve antioxidant and functional properties (Kaukovirta-Norja *et al.*, 2004; Jimenez *et al.*, 2019; Chinma *et al.*, 2021; Chinma *et al.*, 2021). Likewise is fermentation is a traditional method of processing plant foods that also decreases ANFs, enhances nutritional value, antioxidant, health beneficial, and functional properties of legumes and cereals (Adebiyi *et al.*, 2019; Chinma *et al.*, 2020).

According to the available literature, the combined impact of germination and solid-state fermentation (SSF) on the physicochemical, antioxidant activities, digestibility, functional and characteristics of brown finger millet is limited. It is thus important to understand the impact of these treatments on the composition of brown finger millet flours which may provide additional knowledge on the functionality of these grains. Such knowledge will contribute to increasing their utilization and potentials in the food industry, as well as contribute towards attaining food security in developing countries, where they are domesticated. The aim of this study was thus to determine the impact of germination and/or solid-state fermentation on the physicochemical, antioxidant, in vitro digestibility, functional, and thermal properties of brown finger millet flour.

2.0 Materials and Methods (This should be written in Garamond, font 11 with single spacing)

2.1 Materials

Finger millet (dark brown variety) grains and *Saccharomyces cerevisiae* (baker's yeast, Angel Yeast Company, Yichang Hubei, China) were procured from Central Market, Minna, Nigeria. All reagents used for the study are of analytical grade.

2.2 Sample preparation

Cleaned finger millet grains were washed, drained, and dried in air draft-oven (Gallenkamp, Cheshire, UK) at 40 °C for 24 h. The dried finger millet grains were milled and sieved (screen diameter 100 µm) to produce raw finger millet flour (RFMF), which served as control.

3.0 Results and Discussion (This should be written in Garamond, font 11 with single spacing. Maximum of two tables or one table and one figure)

3.1 pH and TTA

The pH of raw finger millet was 6.00 (Table 1), which is close to the value (6.32) reported by Mutshinyani *et al.* (2020) for raw finger millet (dark brown variety). The pH of germinated finger millet flour (GFMF), fermented finger millet flour (FFMF), and germinated-fermented finger millet flour (GFFMF) samples were reduced by 9.09%, 10.61% and 12.12%,

respectively, compared to the raw finger millet. On the other hand, TTA of germinated, fermented, and germinated-fermented FM flour significantly increased by 9%, 4% and 4%, respectively compared to raw finger millet. The reduction in pH values of the treated FM samples could be due to breakdown of complex organic molecules by microorganisms that led to accumulation of organic acids, which increased the acidity. Similar trends were observed by other authors (Adebo *et al.*, 2018; Siddiqua *et al.*, 2019; Chinma *et al.*, 2020) for pH and TTA of germinated and fermented grains.

3.2 Proximate composition

The proximate composition of raw finger millet (Table 1) is in close range with values previously reported by Mutshinyani *et al.* (2020) for dark brown variety of finger millet. The moisture value of samples were $\leq 10\%$ recommended as safe limit for extended preservation of flours. Raw FM contained 9.03 g/100g protein, which increased by 14.73%, 19.27% and 19.60% in germinated, fermented and germinated-fermented finger millet flours, respectively. The increased concentration of protein in the bioprocessed finger millet flour samples could be attributed to synthesis of enzymes by the fermenting or germinating grains, synthesis of newly formed proteins, and degradation of other constituents such as antinutritional factors (ANFs) (Ilowefah *et al.*, 2017; Xu *et al.*, 2019; Ohanenye *et al.*, 2020). Owheruo *et al.* (2019) recorded slight increase in protein value (7.61 to 7.81 g/100 g) of finger millet after 72 h germination. In contrast, reduction in protein content of finger millet after natural fermentation (8-36 h) has also been reported (Gowthamraj *et al.*, 2020). Raw finger millet contained 1.82 g/100 g fat, which decreased by 21.4%, 39.34% and 38.35% after germination, fermentation, combined germination and fermentation processes, respectively. This could be attributed to lipolytic hydrolysis caused by lipase enzyme during germination/fermentation (Adebiyi *et al.*, 2019) or the utilization of lipids as energy sources during solid-state fermentation and/or germination. Ash value of raw finger millet was 2.44 g/100g, and increased by 21.31% and 14.75% after germination, and germination and fermentation, respectively, while a reduction in ash value (28.70%) was recorded after fermentation of FM which could be due to from increased loss of dry matter due to enzyme activities and yeast proliferation during fermentation (Chinma *et al.*, 2020). Crude fiber content increased by 10.10% and 6.48% in germinated, and germinated-fermented FM flour, respectively, compared to the control, whereas a reduction (10.88%) in crude fiber value was recorded in fermented sample. The increase in crude fiber content in germinated FM may stem from formation of new primary cell whereas the observed reduction in crude fiber value after fermentation could partly be attributed to degradation of crude fiber by enzymes (Ilowefah *et al.*, 2017; Chinma *et al.*, 2021).

Table 1. Title Garamond, font 11 with single spacing, Center, All Borders

Parameters	Raw Flour	Germinated FM	Fermented FM	Germinated and fermented FM
pH, TTA and proximate composition pH	6.60	6.00	5.90	5.80
Titrateable acidity (%)	0.10	0.19	0.14	0.14
Moisture (g/100 g)	8.15	8.37	8.42	8.17
Protein (g/100 g)	9.03	10.36	10.77	10.80
Fat (g/100 g)	1.82	1.43	1.10	1.13

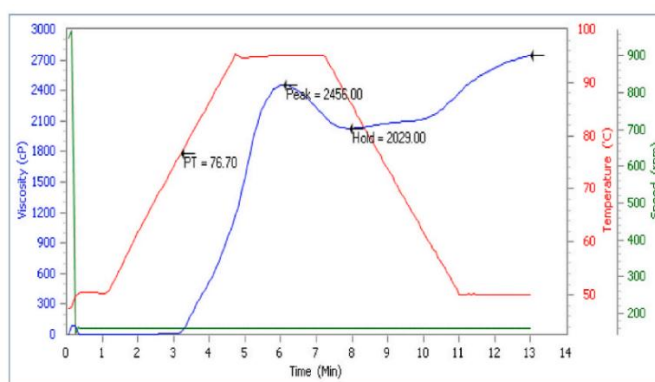


Figure 1. Title Garamond, font 11

4.0 Conclusion (This should be written in Garamond, font 11 with single spacing)

5.0 Acknowledgment (Where necessary. Garamond, font 11 with single spacing)

References (The Harvard style of referencing should be adopted ie. references should be listed in alphabetical order. Maximum of ten references should be cited).

Chinma, C. E., Anuonye, J. C., Simon, O. C., Ohiare, R. O. and Danbaba, N. (2015). Effect of germination on the physicochemical and antioxidant characteristics of rice flour from three rice varieties from Nigeria. *Food Chemistry*, 185, 454-458.

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NOTE

1. Submitted conference paper must not exceed 5 A4 pages with single spacing.
2. Tables must not exceed 2 tables or one table and one figure or two figures.

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CHAPTER 1

MEAT, FISH AND DAIRY PRODUCTS

EFFECT OF MILK TYPE ON THE COLOUR PROPERTIES OF “CUKU”

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Abstract

“Cuku” is one of dairy products consumed in core northern parts of Nigeria. The study evaluated the effect of milk type on the colour properties of “cuku” (Fulani cheese) consumed in Gashua, Yobe state, Nigeria. Three different samples (camel “cuku”, goat “cuku” and cow “cuku”) of “cuku” were purchased from producer was used for the study. Colour properties [lightness (L^*), redness (a^*) and yellowness (b^*)] of samples were measured using a colorimeter (Hunter Lab, USA). The values obtained for colour are significantly different ($p < 0.05$) with the values ranged from 47.53 - 60.90, 2.14 - 9.89 and 20.06 - 30.86 for lightness (L^*), redness (a^*) and yellowness (b^*) respectively. The highest value of lightness (L^*) was observed in cow “cuku” while goat “cuku” have the lowest value. Also, the highest values of both redness (a^*) and yellowness (b^*) was observed in cow “cuku” while the lowest value was observed in goat “cuku” and camel “cuku” respectively. The study showed that cow “cuku” have highest value of lightness, redness and yellowness while the lowest values of lightness and redness was observed in goat “cuku”, and yellowness in camel “cuku”. Also, different milk types influence the colour properties of “cuku”.

Keywords: Colour, “cuku”, cheese, milk, consumer acceptability

Introduction

Milk is entire clean lacteal secretion procured from complete milking of healthy animals such as cow, sheep and goat (Kailasapathy, 2015). Kailasapathy (2015) further reported that milk has considered as almost perfect food and comprises at least 3% milk fat and 8.25% milk solid non-fat. Milk is estimable food that contained nutrients required by human beings for usual growth and development (Aliyu *et al.*, 2019). Milk is a good source of essential nutrients such as protein, fats, carbohydrates, minerals and vitamins (Aliyu *et al.*, 2019; Ali *et al.*, 2022). Cheese is dairy product produced by use of organic acid and rennet (Ali *et al.*, 2022). There are over one thousand types of cheese available in the world (Ali *et al.*, 2022). Blažić *et al.* (2017) revealed that cheese meets the need for nutrients and play essential aspect of tradition and cultural heritage of some countries. The main benefit of cheese is that it is inexpensive source of protein, calcium and fat contents which is very important in the vegetarian meal (Blažić *et al.*, 2017). The traditional dairy products being produced in Nigeria includes “nono”, “wara” and “cuku”. However, it should be noted that “wara” and “cuku” are classified as cheese out of these dairy products. “Cuku”, which is also known as Fulani cheese is a dairy product produced

in the northern part of Nigeria. It is local cheese produced from camel, cow and goat milks. “Cuku” is dry dairy product being consumed by people in the Gashua and other northern parts of Borno state, Yobe state and Jigawa state of Nigeria irrespective of age, tribes and religious affiliation.

The consumption of cheese in the world has increased over years and led to high demand (Martinez-Martínez and Velez-Ruiz, 2019). All the traditional cheese comprises superior quality due to its processing and preservation methods which are of the societal traditions and cultures (Blažić *et al.*, 2017). Since, “cuku” is being produced from three types of milk. Thus, the milk types could affect the colour properties of “cuku”. Colour is a crucial physical property and quality attribute of foods (Martinez-Martínez and Velez-Ruiz, 2019). So, colour could influence the consumer acceptability of foods. Also, there is scanty information on colour properties of “cuku”. The study is aimed to evaluate the effect of milk types on the colour properties of “cuku” consumed in Gashua, Yobe state, Nigeria.

Materials and methods

Three samples (camel “cuku”, goat “cuku” and cow “cuku”) of “cuku” (Figure 1) were purchased from producer in Gashua, Yobe state was used for the study. The colour properties [lightness (L^*), redness (a^*) and yellowness (b^*)] of samples were measured using a colorimeter (Hunter Lab, USA). The samples were evaluated in triplicate. The data obtained from the analyses samples were subjected to analysis of variance (ANOVA) using SPSS version 25.0 software. Means were separated using Duncan’s Multiple Range Test where there was significant difference ($p < 0.05$).

Results and discussion

Table 1 shows the effect of milk type on the colour properties of “cuku”. The values obtained for colour are significantly different ($p < 0.05$) with the values ranged from 47.53 - 60.90, 2.14 - 9.89 and 20.06 - 30.86 for lightness (L^*), redness (a^*) and yellowness (b^*) respectively. The highest value of lightness (L^*) was observed in cow “cuku” while goat “cuku” have the lowest value. The high values of L^* could be attributed to the heat treatment undergone during the process of “cuku” as Aydemir and Dervisoglu, (2010) revealed that during heat treatment, some proteins in cheese form gel particles which cause scatter light and then led to increment in L^* value. Also, the variations in L^* values might be due to salt content of “cuku” as Kaya (2002) reported that difference in L^* values of cheese samples may be related to salt distribution in cheese structure and swelling phenomena caused by concentration variation of salt in brine. Kaya (2002) further stated that high concentration of salt leads to an increment in lipid oxidation and then change in the colour of cheese. Also, the highest values of both redness (a^*) and yellowness (b^*) was observed in cow “cuku” while the lowest value was observed in goat “cuku” and camel “cuku” respectively. The value of L^* (88.09) reported for “aro” cheese by González *et al.* (2018) was higher than the value obtained for “cuku”. Determination of L^* value (lightness) and b^* (yellowness) parameters are important colour values of cheese and determine the interior and surface of the cheese samples (Aday and Yuceer, 2014). Differences in b^* value results of “cuku” could be attributed to differences in milk type as Aday and Yuceer (2014) reported that differences in results of mihalic cheese

were due to differences in bacterial flora and sources of milk. Also, it should be noted that cow “cuku” have high b^* value and this is in line with Aday and Yuceer (2014) who reported that cow can pass dietary carotenoids to the milk while sheep, goats and other animal cannot pass dietary carotenoids to the milk. The values of a^* and b^* obtained for “cuku” were higher than the value of a^* (0.39) and b^* (13.14) of “aro” cheese reported by González *et al.* (2018). The differences in the values of L^* , a^* and b^* of “cuku” could be attributed to differences in milk type and moisture content of “cuku” as Aday and Yuceer (2014) revealed that age, moisture, lipolysis, proteolysis and ripening conditions influence the colour properties of cheese. In addition, Okpala *et al.* (2010) revealed that heat treatments and sources of milk in cheese making might have resulted in variations in colour of cheese while Rashidinejad *et al.* (2017) reported that differences depends on source of milk, composition of milk, ripening time, processing methods and texture of all types of cheese.

Conclusion

The study showed that cow “cuku” has highest value of lightness, redness and yellowness. However, different milk types influence the colour of “cuku”.

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Figure 1: Sample of camel, cow and goat “cuku”

Table 1: Effect of milk type on colour properties of “cuku”

Sample	L^*	a^*	b^*
Camel	54.00 ^b	4.30 ^b	20.06 ^c
Goat	47.53 ^c	2.14 ^c	25.80 ^b
Cow	60.90 ^a	9.89 ^a	30.86 ^a

Mean values with different superscript within the same column are significantly different ($p < 0.05$), L^* : Lightness, a^* : Redness, b^* : Yellowness

EFFECT OF SMOKING AND STORAGE CONDITIONS ON SOME QUALITY ATTRIBUTES OF SMOKED CATFISH (*Clarias gariepinus*)

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ABSTRACT

This study was carried out to investigate the effect of smoking conditions on some quality attributes of smoked catfish (*Clarias gariepinus*). Sixty samples of fresh catfish were purchased at Odogunyan market, Ikorodu, Nigeria. The samples were divided into four equal portions and smoked. Smoked samples were analyzed for free fatty acid (FFA), thiobarbituric acid (TBA), trimethylamine (TMA) and sensory characteristics using standard methods. The results showed that the FFA values of smoked fish samples increased as the storage day increases. TBA values in this study were within the range of 0.21-0.47 from day 0-day 15. TVB values in this study showed sample ADF reduced from 6.52 – 6.47, 6.56-6.48, for sample FAD 6.58-6.51, for sample PAS and 6.55-6.46 on the 6th day.

Key words: Smoking, Catfish, Quality, Storage, Acceptability

INTRODUCTION

Fish contains high quality protein, amino acids and absorbable dietary minerals and it is particularly valued for its protein which is of high quality compared to those of meat and egg (Ojutiku *et al.*, 2009; Adeyeye *et al.*, 2015a) and its taste. It is rich in omega-3-fatty acid that is heart friendly as well as protein and minerals which reduce anemia and protein energy malnutrition (Ojutiku, *et al.*, 2009, Adeyeye *et al.*, 2015a). However, fish is highly perishable because it provides favourable medium for the growth of microorganisms after death (Adeyeye *et al.*, 2015b; Oparaku and Mgbenka, 2012).

The shelf-life of smoked fish product is usually extended primarily due to the reduced water activity as reported by Eyo, 2001 who carried out a study for short time storage of dry fish and found out that the moisture content of the dried fish must be less than 30% to prevent mold and bacterial infestation. Smoked seafood products vary widely in microbial stability; however, this depends on the nature and degree of severity of smoking. Heavily salted, hard smoked products have water content that is too low to support microbial growth and present

little or no public health hazards (Eyo, 2001). However, the application of heat to dehydrate fish does not only remove water but excess of such heat can affect the nutritional content of the dried fish (Eyo, 2001). Studies have shown that smoking causes loss of lysine which is proportional to the temperature and duration of smoking (Eyo, 2001).

Eyo, (2001) reported that smoking prolongs shelf life, enhances flavor and increases utilization of smoked fish in soups and sauces. It is therefore important to ascertain effects of smoking conditions on the quality of smoked catfish. Therefore, this study was carried out to investigate the effects of smoking and storage conditions on some quality attributes of smoked catfish (*Clarias gariepinus*).

MATERIALS AND METHODS

Materials

Fresh catfish (*Clarias gariepinus*) samples used for this study were purchased from Odogunyan market, Ikorodu. Wood and charcoal as well as other materials like salt, knife, bowl (small and big sizes) were also obtained from the same market.

Methods

Smoking of fish

Fish samples were smoked according to the drum smoking method described by Adeyeye, *et al.*, 2015a. The fishes were slaughtered and then gutted, washed and salted and was left for some minutes. The samples were divided into four equal portions. The first and second portions were smoked with charcoal for 2h at 89°C (FAD) and 2h 15 m at 85°C (SPA) respectively. The third and fourth portions were smoked with wood for 1h and 30 m at 120°C (ADF) and 1h 45 m at 105°C (PAS) respectively. This was done to determine the effects of smoking methods, fuel and time on the quality of smoked fish. The smoked fish samples were kept in a desiccator to cool, packaged in Ziploc bags and kept at ambient temperature for laboratory analyses.

Quality analysis

The pH, free fatty acids (FFA), trimethylamine value (TMA), thiobarbituric Acid (TBA) and total volatile base- nitrogen (TVB-N) were determined using AOAC (2000) method.

Statistical Analysis

Data were analyzed using SPSS Version 21.0 for windows (IBM Corporation, New York, USA). Variability within the means was separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$).

RESULTS AND DISCUSSION

The results of free fatty acid, thiobarbituric acid, total volatile base nitrogen and trimethylamine are shown Table 1. The values of the free fatty acid increased as the number of days increased. It was observed from the study that the values obtained at day 0 did not changed at day 3 for all the samples but increased steadily after day 3. The values in this study increase as the day increases. Similar results have been reported by Ozogul and Balikci (2013)

for smoked mackerel from 2.46-7.33 after a storage period of 9 months. FFA values of 1.02 to 1.26% were reported for smoked bonga shad by Adeyeye *et al.* (2015b) which is lower when compared to the values obtained in this study which may be due to effects of smoking methods and fish type.

The thiobarbituric acid (TBA) values are commonly used to measure the level of rancidity. It was found that storage affected thiobarbituric value due to oxidation of fish fat during storage. It was also found that smoking time and temperature also have influence on thiobarbituric acid values as could be seen in SPA and PAS (Table 2). The increased in TBA values in the smoked catfish was probably originated from the breakdown of oxidation products, mainly malonaldehyde, during smoking due to the high temperature and fat oxidation during storage period (Adeyeye, 2015a, 2015b). The increase in thiobabituric acid after day 3 may reduce the shelf life of the fish samples. The results in this study were lower when compared to the value (6.50 mgMol/100g) reported by Adeyeye, 2015b in smoked silver catfish and Nigerian tongue sole.

The values of total volatile base nitrogen and trimethylamine are shown in (Table 2). The total volatile base nitrogen (TVB-N) values of all the smoked fish samples have not reached the limit of 30mg/100g (Daramola *et al.*, 2007) after 15 days of storage period and this further confirms the quality of the fishes smoked with charcoal and wood. The TVB values found in this study are lower than the values reported by Magawata and Musa (2015) for smoked *Clarias gariepinus*. The results of TVB from this study showed that the values of nitrogen contents of the catfish samples steadily reduced after 3 days of storage. Sample ADF reduced from 6.52 – 6.47, 6.56-6.48 for sample FAD, 6.58-6.51 for sample PAS and 6.55-6.46 on the 6th day (Table 2). Trimethylamine is a reduction product of trimethylamine oxide (TMAO) during spoilage and ammonia is mainly formed as a product of protein break-down. Trimethylamine (TMA) is one of the volatile amines plus ammonia which can be used as an index of spoilage (Da Silva, 2002). The values obtained in this study were within the range of 0.21-0.47 from day 0-day 15. The values in this study were lower while compared to the value 5.00 mgN/100g for doubtful quality specified U.S.F.D.A (Da Silva, 2002). Trimethylamine is associated with fatty substance and is responsible for the fishy smell of spoiled fish. The lower level of trimethylamine in the samples indicates that there was low rate of decomposition of fish protein and the fish samples are of good quality.

Table 1: Free fatty acid and thiobarbituric acid contents of smoked fish over a period of 15 days

Free Fatty Acid

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	2.67±0.15 ^{ab}	2.67±0.15 ^{ab}	4.03±0.15 ^a	4.03±0.15 ^a	4.90±0.20 ^a	5.40±0.10 ^a
FAD	2.47±0.15 ^b	2.47±0.15 ^b	3.83±0.15 ^{ab}	3.83±0.15 ^{ab}	5.03±0.15 ^a	5.90±0.70 ^a
PAS	2.83±0.21 ^a	2.83±0.21 ^a	3.70±0.20 ^b	3.70±0.20 ^b	4.80±0.10 ^a	5.23±0.15 ^a
SPA	2.70±0.10 ^{ab}	2.70±0.10 ^{ab}	3.97±0.15 ^{ab}	3.97±0.15 ^{ab}	4.87±0.15 ^a	5.33±0.15 ^a

Thiobarbituric Acid

ADF	0.01±0.00 ^{ab}	0.01±0.00 ^{ab}	0.11±0.00 ^c	0.11±0.00 ^c	0.16±0.00 ^b	0.19±0.00 ^{ab}
FAD	0.01±0.00 ^b	0.01±0.00 ^b	0.09±0.00 ^a	0.09±0.00 ^a	0.17±0.00 ^a	0.20±0.00 ^a
PAS	0.02±0.00 ^a	0.02±0.00 ^a	0.10±0.00 ^b	0.10±0.00 ^b	0.17±0.00 ^a	0.19±0.00 ^b
SPA	0.01±0.00 ^a	0.01±0.00 ^{ab}	0.11±0.00 ^c	0.11±0.00 ^c	0.17±0.00 ^a	0.19±0.00 ^c

Sixty samples were produced and analyses were done in triplicates to obtain mean values. Means were separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$). Mean $\pm$ standard deviation with same superscript along the column is not significantly different at ($p \leq 0.05$).

Key

Sample FAD: smoked with charcoal for 2hrs at 89°C

Sample SPA: smoked with charcoal for 2hrs 15 min at 85°C

Sample ADF: smoked with wood for 1hr and 30 min at 120°C

Sample PAS: smoked with wood for 1hr 45 min at 105°C

Table 2: Total volatile base acid and trimethylamine acid contents of smoked fish over a period of 15 days

Total Volatile Base

Sample	Day 0	Day 3	Day 6	Day 9	Day 12	Day 15
ADF	0.63±0.06 ^a	0.63±0.06 ^a	1.30±0.10 ^a	1.30±0.10 ^a	1.90±0.10 ^b	2.37±0.15 ^{ab}

FAD	0.67±0.06 ^a	0.67±0.06 ^a	1.27±0.06 ^a	1.27±0.06 ^a	1.93±0.15 ^b	2.23±0.15 ^b
PAS	0.70±0.10 ^a	0.70±0.10 ^a	1.33±0.06 ^a	1.33±0.06 ^a	2.20±0.10 ^a	2.57±0.15 ^a
SPA	0.67±0.12 ^a	0.67±0.12 ^a	1.37±0.15 ^a	1.37±0.15 ^a	1.93±0.15 ^b	2.33±0.15 ^{ab}
Trimethylamine						
ADF	0.21±0.02 ^b	0.21±0.02 ^b	0.31±0.01 ^a	0.31±0.01 ^a	0.42±0.02 ^a	0.45±0.02 ^a
FAD	0.23±0.01 ^{ab}	0.23±0.01 ^{ab}	0.33±0.01 ^a	0.33±0.01 ^a	0.43±0.02 ^a	0.47±0.01 ^a
PAS	0.25±0.01 ^a	0.25±0.01 ^a	0.39±0.02 ^c	0.39±0.02 ^c	0.45±0.02 ^a	0.46±0.01 ^a
SPA	0.24±0.02 ^a	0.24±0.02 ^a	0.36±0.02 ^b	0.36±0.02 ^b	0.44±0.02 ^a	0.46±0.02 ^a

Sixty samples were produced and analyses were done in triplicates to obtain mean values. Means were separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$). Mean $\pm$ standard deviation with same superscript along the column is not significantly different at ($p \leq 0.05$).

Key

Sample FAD: smoked with charcoal for 2hrs at 89°C

Sample SPA: smoked with charcoal for 2hrs 15 min at 85°C

Sample ADF: smoked with wood for 1hr and 30 min at 120°C

Sample PAS: smoked with wood for 1hr 45 min at 105°C

CONCLUSION

From the research study, it can be shown that the FFA, TBA, TVB-N and TMA values of the samples decreased during the storage period. This decrease could be attributed to fat oxidation and decarboxylation of amino acid in the samples. This lowers the quality of the smoked fish.

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CONTROL OF PARTICLE SIZE IN THE PROCESS STANDARDIZATION OF DAMBUNNAMA: A SHREDDED, DRY MEAT PRODUCT

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Abstract

The study was aimed at controlling the average sizes of meat shreds in the processing method of *dambunnama*. Fresh beef from skeletal muscle with an average moisture content of 74% was used. Two samples (D1 and D2) were produced using the pounding (*dakan*) method, and the shearing (*tuqe*) method respectively. Hand sorting and screening of the shredded meat were included in the former method. Screens of mesh sizes 3, 4, 5, 6, with aperture openings of 0.265, 0.187, 0.157, 0.132 inches respectively were used. The shreds of D1 retained on mesh number 4, and the shreds of D2 obtained due to frequent stirring were each separately stir fried at an average temperature of 108°C for 20 minutes and 30 minutes respectively. The samples were subjected to sensory analysis (Texture, Taste, Aroma, Appearance, and Overall Acceptability) using a panel of fifteen members, based on a nine-point hedonic scale. Data was subjected to Analysis of Variance (ANOVA) and a post hoc analysis using Duncan's method at $P \leq 0.05$. Sample D1 had the highest means (8.07, 8.21, 8.21, 8.21, 8.27 respectively), in all the parameters tested. It was concluded that uniform shred sizes resulted in a product with preferred sensory attributes.

Keywords: Dambunnama, Shredding, Screening, Sensory Attributes

1.0 Introduction

Size distribution is often of critical importance to the way a material performs when in use or during processing. Sieve analysis is the first choice in particle size analysis and quality control due to its simplicity, efficiency and low cost (Yusuf and Garba, 2021). Sieving is a physical method of separating mixtures and it consists of passing a mixture of particles of different sizes through a sieve or a screen. The smaller particles pass through the pores of the sieve and the larger ones are retained on the sieve. The time for a sieving process depends on the characteristics of the material, the volume of the initial sample, the intensity of the sieving, the nominal aperture of the sieve, the characteristics of the screening surface, and the environmental conditions (CISA, 2020). The separating action depends on the character of the particle being separated and the forces on the particle which cause the separation. The important characteristics of the particles are size, shape and density. A Sieve is generally made up of a metallic perforated plate that has either square, round, or rectangular holes, and the plate is soldered to a frame (ISO, 2013).

Meat contains a number of important nutrients that are needed by the human body for carrying out vital metabolic functions. These are proteins, fat, vitamins, minerals and other bioactive components, and small quantities of carbohydrates. Shelf life and maintenance of meat quality are influenced by a number of interrelated factors including holding temperature, which can result in detrimental changes in the quality attributes (Yusuf, *et al.*, 2019). *Dambunnama* is a shredded, dehydrated meat product that is produced in most parts of northern Nigeria from the meat of ruminant animals or from poultry. It is usually prepared

using either one of two common procedures; *dakau* and *tuqe*, with variations in the process parameters. The product is locally prepared with the aim of extending the shelf life of meat, providing variety, and for its individual distinct texture and flavor. The potential of developing *dambunnamainto* a conventional product with stable storage features requires the development and adoption of a standard procedure that gives precise and reproducible results. This will require the standardization of existing methods, and the generation of data on the raw materials, processing methods and parameters, and on the final product characteristics. The study was aimed at controlling the sizes of the meat shreds prior to stir frying. Sensory evaluation was used as a tool to assess the consumer preference between the two samples.

Materials and Methods

Sample Collection and Preparation

Fresh beef from the skeletal muscle of the hind quarters of a medium aged healthy cow with an average moisture content of 74% was used in producing the samples. Preliminary preparation operations included trimming of surface fat and visible contamination, washing and mopping up of surface moisture, and cutting into pieces of approximately 2cm cubes. The meat pieces were then divided into two equal portions of 3000g each, one portion was labelled sample D1, while the other portion was labelled sample D2. The initial preparation methods for the two samples were similar with respect to the softening of the seasoned and spiced meat. The methods of shredding were however different. The distinct difference in the samples occurred as a result of the variations in the preparation methods for obtaining the shred sizes of the final product. The local *tuqe* preparation method was adopted completely in the preparation of sample D2, while the procedure of the preparation of sample D1 differed from the local *dakau* preparation method in shred standardization through sieve analysis. The two samples were separately cooked until each became very soft, evidenced by the easy piercing of a fork through a piece. Sample D1 was gently pounded, giving shreds of different sizes, with some hard tissue or tendons. It was then hand sorted and air dried for one hour on a stainless-steel tray with periodic separation of clumps using a wooden spoon. Sieves of mesh sizes 3, 4, 5 and 6 were used in the size sorting of the meat shreds. The retained shreds from mesh number 4, with an average shred size of 0.195 inches, that compare well with the average shred size of the locally hand sorted *dakau* with average shred size range of between 0.191 to 0.221 inches, were adopted as sample D1. The stir frying was slow and gradual, with the average meat temperature not exceeding 110°C, taken at 10 minutes intervals, until the shreds turn to a uniform golden brown colour, with no evidence of steam coming out of the pan. The product was then spread on a stainless-steel tray to aid in its cooling and the escape of any residual moisture.

The traditional method of *tuqe* or stirring, was adopted wholly in the preparation of sample D2. The softened meat was continuously stirred to form shreds, while the oil was periodically added. Therefore, as shreds were formed due to the stirring, they were also being stir-fried. Different sizes of shreds were formed, with some pieces of the meat not completely disintegrated when the frying process was terminated. The change of colour of the large shreds and pieces to golden brown was used as a yardstick for terminating the stir frying of sample

D2. The product was then spread on a stainless-steel tray to cool down and allow for the escape of residual gases.

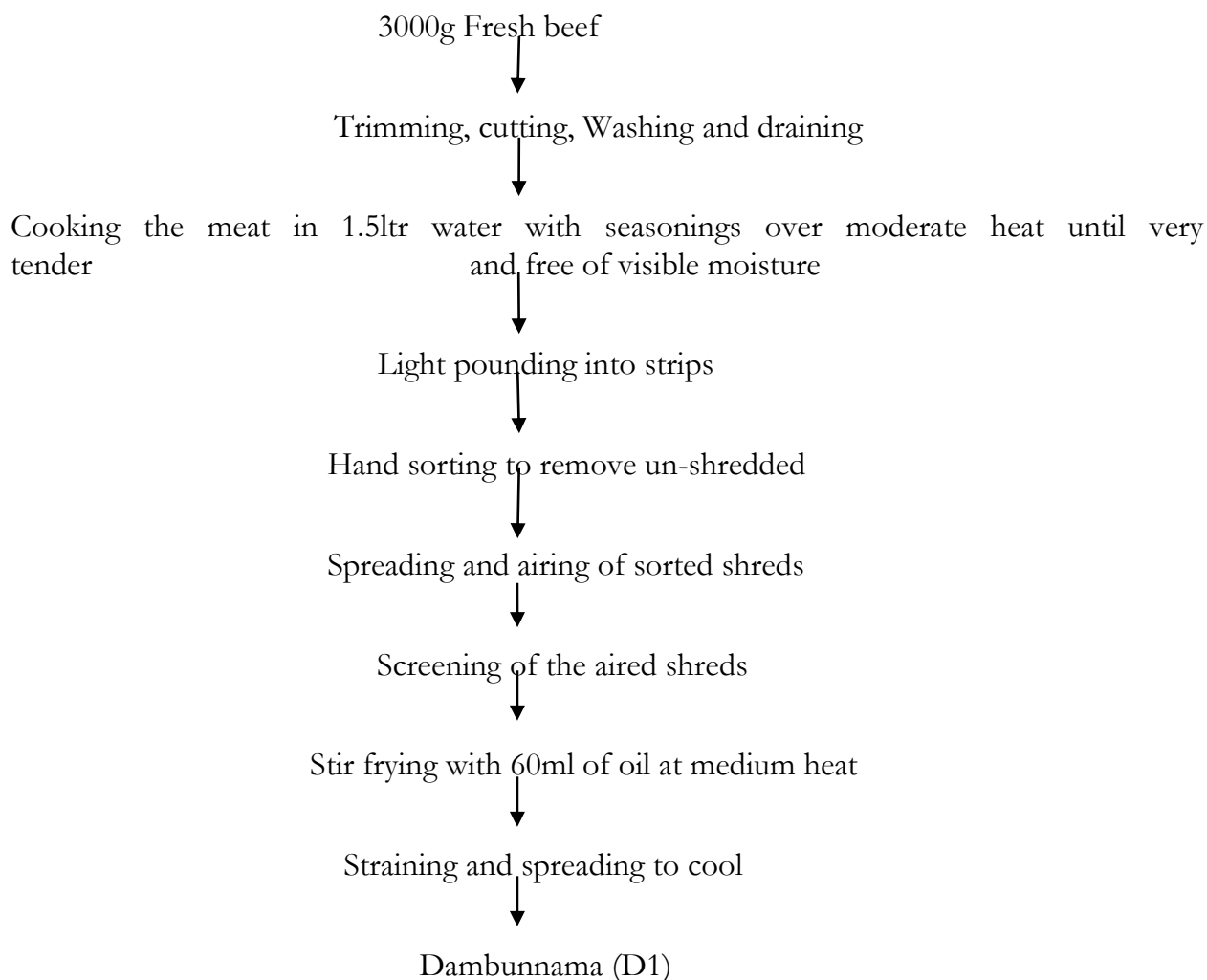


Figure 1: Flow Chart for the preparation of Dambunnama, D1

2.2 Sieve Analysis

To prepare the sample for screening, it was first hand sorted to remove poorly shredded pieces, fatty pieces, and tendons. It was spread and aired for one hour with periodic stirring to separate agglomerated pieces. The hand sorted and aired sample (a total of 3126 grams after cooking) was then divided into 31 portions of approximately 100.8 grams each to permit each of the particles an opportunity to present themselves on the test sieve surface (QMJ Group Ltd, 2021). The selection of the sieves was based on obtaining particle sizes that had more uniform characteristics than those obtained in the traditional hand sorted *dambunnama*. For the sieving procedure, single sieving was carried out using the method outlined by Retsch (2009), with four test sieves of mesh sizes 3, 4, 5, and 6 (0.265, 0.187, 0.157, 0.132 inches respectively). These were used singly to determine the percentages of undersize and oversize. The sieves

were made of metallic plates with rectangular apertures. The empty sieves were first weighed and the weights recorded. Then one portion of the 31 portions was placed on the sieve with mesh number 6 that had a diameter of 20mm and sieving commenced for 5 minutes. The tapping and throw technique that is mostly characteristic of the hand sieving procedure was adopted. It involved a horizontal circular motion that overlaps a vertical motion which was created by the tapping impulse. The oversize of mesh number 6 was transferred to mesh number 5, that of mesh number 5 to mesh number 4, and that of mesh number 4 to mesh number 3. The transfers were done after rigorous sieving for five minutes (Retsch, 2009). The sieving time of five minutes was adopted because during test sieving, it produced a difference in the weights of the undersize of less than 1% between the last two successive readings (Advantech Manufacturing, 2001) from all the four sieves. This procedure was repeated for the rest of the 30 portions. The sum weights of the oversize and undersize meat shreds from each sieve were determined after the sieving process. The cumulative method was used to weigh the sample retained in each sieve. The amount retained is then calculated using the formula:

$$\% \text{ Retained} = \frac{W_{\text{sieve}}}{W_{\text{total}}} \times 100$$

Where W_{sieve} is the mass of the aggregate in the sieve, and W_{total} is the total mass of the aggregate. The cumulative percent of the aggregate retained in each sieve was calculated according to the method of Retsch (2009), then the cumulative percent of the aggregates passing through was calculated by subtracting the cumulative percent retained from 100.

$$\% \text{ Cumulative Passing} = 100\% - \% \text{ Cumulative Retained}$$

Presentation and analysis of the results data was made by directly plotting the sieve size versus percentage retained, and the sieve size versus percent cumulative on same axis.

2.3 Sensory Evaluation of the Products (D1 and D2) and Statistical Analysis

The final stir-fried products of samples D1 and D2, were subjected to sensory assessment by a 15-member test panel, based on a nine-point hedonic scale ranging from 9 being extremely like to 1 being extremely dislike, respectively. The parameters tested were taste, texture, aroma, appearance, and overall acceptability. Data obtained from the sensory evaluation was subjected to Analysis of Variance (ANOVA) to generate means, which were further subjected to T-test for preference testing at 5% significance level, to determine the differences in the parameters tested (Lawless and Heyman, 2019).

Results and Discussion

Sieve analysis

Size distribution is often of critical importance to the way a material performs when in use. Hand sorting of the pounded meat pieces was aimed at removing large pieces that could present a problem in the course of sieving, because heavier particles tend to roll to the lowest portion and outer perimeter of the sieve thereby preventing effective sieving. Airing of the

meat shreds was done to eliminate fluid bridges and adhesive forces as a result of residual moisture on the sample surface which contributed to the agglomeration of the shreds after pounding. Agglomerates falsify the particle size distribution, because particle collectives are measured instead of individual particles with the result that the percentage of coarse particles is too high (Restch,2009).

The sieving method that constituted of a back and forward movement of the sieve was meant to circulate the sample around the whole sieving surface (CISA, 2020). The periodic tapping action that produced a vertical throwing motion overlaid with the horizontal circular motion aided in distributing the sample over the sieving surface (Restch, 2009), and facilitated the passing of the shreds through the apertures by reducing blinding or blocking. The throwing motion was also necessary because shreds had irregular shapes, but were assumed to be spherical (Advantech Manufacturing Publication, 2001; Albright, 2008) whose sizes can be narrowed down with the help of sieving. The particles that were smaller than the openings passed through the sieve, while larger particles were retained. The results of the sieve analysis are presented in table 1.

Table 1: Results of Sieve Analysis of Sample D2 (*dakau*)

Sieve mesh size	Sieve size (µm)	Sievesize (mm)	Massofshreds retainedineach sieve (g)	% Retained	% Cumulative
3	6730	6.73	300.6	9.62	99.99
4	4760	4.76	2617.1	83.72	90.37
5	4000	4.00	152	4.86	6.65
6	3360	3.36	56	1.79	1.79

From the table, the results indicate that sieve with mesh size 3 retained 9.62% of the shreds, which constituted the biggest in size as compared to the rest of the shreds. The particles that passed through mesh number 3 had sizes close to the size of the nominal aperture of this sieve or much smaller.

Sieve with mesh size 4 retained 83.72% of the shreds, and a cumulative of 90.37%, which means that the shreds were a part of those that passed through mesh size 3, of which some were retained on mesh number 4, while those that passed through the latter had a cross section smaller than the mesh opening. Mesh size 3 served as a relief sieve that removed some of the burden (Advantech Manufacturing Publication, 2001) for mesh number 4 sieve, thereby increasing the effectiveness of subsequent sieving.

The bulk of the shreds (83.72%) were retained in mesh number 4, indicating that a high percentage of shreds had similar forms and sizes. This is responsible for important physical and chemical properties such as flowability and surface reaction (Restch, 2009). The use of sieve analysis in the modified *dakau* method of *dambunnama* production was meant to set a

standard for production and quality control, that will result in easy handling, low investment costs, with precise and reproducible results in a comparably short time.

Sensory analysis

The results of the sensory assessments of the two products indicate that the parameter with the highest mean score was the overall acceptability of sample D1. The overall acceptability gives a summary of the acceptance of all the parameters tested in a sample, with high values indicating high acceptability.

In terms of texture, this preference could be attributed to the uniformity and the fluffiness of sample D1. Since texture is one of the most important attributes used by consumers to assess food quality (McKenna 2018), the texture of sample D1 played a very important role in its preference over sample D2.

In sample D2, different particle sizes were arbitrarily created as a result of the continuous stirring of the softened meat pieces. This endless combination of particle sizes constituted those that were fragile, which required minimal heat exposure and short processing times. The sample also constituted of medium and relatively large particle sizes that required moderate and long processing times respectively. The different combination of these particle sizes caused processing challenges in terms of the sensitivity of the fragile particles being prone to over-processing and heat damage (Tetra Pack, 2016). The process duration and temperature of exposure of sample D2 resulted in giving its particles a golden brown, deep brown and random black colour. The random black particles were mostly small particles or shreds, which were the most affected by the temperature and time of processing. This resulted in their pyrolysis, a chemical degradation process that occur at high temperatures producing black solids or char (TetraPack Publication, 2016). Pyrolysis was prevented in sample D1 because of sorting and sieve analysis, which created uniform-coloured particles of a golden-brown appearance. This was as a result of the minimum temperature and time of exposure that was crucial to the desired and consistent quality attributes.

Conclusion

Particle size in foodstuff crucially influences organoleptic properties, such as taste and mouthfeel. The particle size in the production of *dambunnama* plays an important role in determining the quality of the final product and plays a big role during moisture removal using heat processing. The study highlighted that the use of sieving to control uniformity in particle size, greatly affected the final quality of *dambunnama*. The controlled preparation methods and the final product characteristics of sample D1 (*dakan*) resulted in its preference over sample D2 (*tuqe*). The analyzed sensory data proved the preference of sample D1 in all the parameters tested including the overall acceptability. Therefore, for establishing precision and reproducibility in the processing method of *dambunnama*, and in the final product quality characteristics, the preparation method of sample D1 could be adopted as a standardized procedure of commercial production of *dambunnama*.

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NUTRIENT DIGESTIBILITY, AND CARCASS MEASUREMENTS OF RABBITS FED ON GRADED LEVELS OF DRIED OKRA LEAVES (*ABELMOSCHUS ESCULENTUS*)

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Abstract

Forty-five unsexed rabbits crosses (Chinchilla X Newzealand white) 5-6 weeks old with average weight of 720g were used in a 70 days feeding trial to evaluate the nutrient digestibility and carcass measurements of growing rabbits fed on varying levels of dried okra leaves. The rabbits were assigned into five treatment groups containing dried okra leaves (DOL) at 0.00%, 2.50%, 5.00%, 7.50% and 10.00% inclusion levels for dietary treatments (T1, T2, T3, T4 and T5) respectively. Each treatment consisted of 9 rabbits and replicated thrice with each replicate consisting of 3 rabbits in a completely randomized design. Data collected were subjected to one-way analysis of variance (ANOVA) using a general linear procedure of SAS (2007) and significant means were separated by Duncan's multiple range test of same statistical package at 5% level of probability. Carcass characteristics of growing rabbits fed graded levels of dried okra leaves indicated that live weight, carcass weight, dressing percentage, loin, hind limb, fore limb, tail, liver and kidney were not differ significantly ($P>0.05$) influenced by the diet. Neck, chest and heart of rabbits fed on 2.50% dried okra leaves have highest significantly ($P<0.05$) of (3.91 %, 10.99 % and 0.27 %) highest compare to those on the groups fed diets containing 0.00 % , 5.00 % , 7.50 % and 10 % dried okra leaves. difference ($P<0.05$). It was concluded that dried okra leaves can be included in diets for growing rabbits and 2.50% level of dried okra leaves inclusion is recommended for adoption by farmers to maximize nutrient digestibility and nitrogen utilization

KEY WORDS: Okra leaves, Nutrient intake, Nutrient digestibility, Rabbits

Introduction

The rabbit (*Oryctolagus cuniculus*) is the most productive meat producing among all domesticated animals. The feeding habits offer no appreciable competition with man. This is because it can subsist on green as basal diets (Ajayi *et.al.*, 2005). The combinations of these characteristics are unique. In addition to this, rabbits have a number of other characteristics that might be advantageous to subsistence farming system, such as their small body size, short generation interval with a relatively short gestation period average of 30 – 31 days (Bolarin *et.al.*, 2013). The daily weight gain is high in proportion to the body weight which gives them a rapid growth rate, and sexual maturity is early. These factors result in the rabbit

reaching the weight of a sexually mature animal 30% faster than other animals (Asaolu *et.al.*,2010) and also make rabbits suitable as meat producing small livestock in developing countries (Doreddula *et.al.*,2014). This study was designed to investigate the effect of feeding with dried okra leaves on nutrient digestibility and **carcass characteristics** for growing rabbits.

Materials and Methods

Study Site: The experiment was conducted at the rabbitary unit of the Directorate of University Farms (DUFARMS) Federal University of Agriculture Alabata road, Abeokuta, Ogun state.

Source of Ingredients: The forage okra (*Abelmoschus esculentus*) leaves were purchased from local farmers in Igboora, Oyo State. The fresh okra leaves were air-dried by spreading on concrete floor until crispy to touch. The dried okra leaves were milled before being incorporated into the concentrate diet and samples were taken to the laboratory for determination of:

Proximate composition: Dry matter, crude protein, ether extract and ash were determined according to AOAC (1980). **Phytochemical analysis:** Quantitative phytochemical analyses for determination of anti-nutrients were carried out to assess the presence of tannins, saponins, alkaloids, flavonoids, phenol.

Experimental Animals: Forty-five (45) unsexed rabbits crosses (Chinchilla X Newzealand white) of 5 - 6 weeks of age and weight range of 720g-750g were used in the ten week feeding trial and were assigned to 5 treatment groups using completely randomized design of 9 rabbits per treatment. The cages were slightly raised above the floor for easy collection of faeces and cleaning. Plastic drinkers metallic feeding troughs were provided in each cage. The drinkers were washed daily. The rabbits were fed ration of 100g in two installments at 8.00 am and 4.00pm. Diet 1 was the control and had no dried okra leaves, variation in the diets were achieved by adding 2.50%, 5.00%, 7.50% and 10.00% respectively. Each of the diet contained at least 17% crude protein.

Data Collection

Nutrient Digestibility: The digestibility trial was conducted during the 6th week of the experiment. Three rabbits were randomly selected from each treatment for total faecal collection. The animals were allowed three days adaptation period followed by five days faecal collection. The amount of faeces voided daily was weighed and allowed to air-dry at room temperature for 2-3 days before re-weighing again. Later the air-dried faeces were oven-dried at 100°C for 24 hours until constant weight was achieved. Dried samples were bottled, ground and stored in air-tight container for laboratory analysis.

Carcass Evaluation: At the end of the experiment (ten weeks) all the rabbits were slaughtered. Prior to slaughtering, the rabbits were tagged, fasted for 12 h and weighed to determine the final live weight. The fur was removed by scalding. Evisceration was carried out immediately by removing the viscera and intestine. The weight of the carcass, head and

internal organs were taken. Five gram samples of the left thigh muscles were collected from all the animals for **proximate analysis** of the nutrient content (protein, fat and ash). The dressed carcass was the portion of the animal remaining after the removal of the head, feet, skin (pelt) and the visceral organs including the kidneys. The dressing percentage was calculated by expressing the dressed weight as a proportion of slaughter weight.

$$\text{Dressing percentage (\%)} = \frac{\text{Carcass weight (g)} \times 100}{\text{Live weight (g)}}$$

Analyses of Samples: Proximate composition of the feed and other samples such as the faecal and urine samples were determined according to AOAC (1980) method of analysis.

Statistical analysis: Data collected were subjected to one-way analysis of variance in a Completely Randomized Design (CRD). Data were analysed using SAS. Package. Significant means were separated and compared using Duncan Multiple Range Test of the SAS package at 95% level of probability.

Results and Discussion

Nutrient Digestibility: Table one shows the digestibility of dry matter, ether extract and nitrogen-free extract which showed no significant difference ($P > 0.05$) among the treatments. However, the digestibility of crude protein, crude fibre and ash were significantly different ($P < 0.05$) but did not follow any pattern. Bolarin *et.al.*, (2013) made similar observation in broiler diets. Crude protein digestibility values reported in this study indicated a high efficiency in crude protein utilization. The present digestibility values were generally higher than the values reported by ⁵ in the tropics. In this study, the values obtained for dry matter and crude protein is in agreement with the findings of (Doreddula *et.al.*, 2014).

Carcass Parameters : The carcass measurements of the rabbits and the various body components expressed as percentage of slaughter weights are shown in **Table two**. The weight of the rabbits before fasting and the slaughter weights were not significantly difference ($P > 0.05$) in all the diets. The slaughter weight obtained in this study ranges from 1100.00g to 1450.33g which is lower than the range of 1695.00g to 2050.00g obtained for rabbits of similar ages. The differences in slaughter weight may be due to breed difference. Nwachukwu *et.al.*, (2014) observed that dressing percentage will tend to be 50% or less if the rabbit slaughtered is young or thin. The body components / organs measured were head, skin (pelt), feet, heart, lungs, kidneys, gastro-intestinal tract, stomach, small and large intestines, caecum, and kidney fat. They were all weighed and expressed as percentage of slaughter weights and subjected to analysis of variance.

Conclusion: The results of this study showed up to 10% of dried okra leaves in the diets of growing rabbits without significant deterioration in the nutrient digestibility and carcass measurements of growing rabbits. However, further studies should be conducted to investigate the possibility of including dried okra leaves in the diets of pregnant and lactating does.

Table 1: Nutrient digestibility of rabbits fed diets containing varying levels of okra dried leaves (*Abelmoschus esculentus*)

Parameters	Levels of Inclusion of okra dried leaves (ODL) (%)					SEM
	0.00	2.50	5.00	7.50	10.00	
Dry Matter	71.34	71.43	70.93	72.52	71.95	0.31
Ash	63.54 ^a	52.57 ^{ab}	57.36 ^{ab}	54.88 ^{ab}	38.81 ^b	2.77
Crude protein	74.87 ^a	71.32 ^{ab}	71.57 ^{ab}	70.28 ^b	69.03 ^b	0.66
Crude fibre	76.79 ^{ab}	76.70 ^{ab}	75.14 ^b	77.07 ^a	74.68 ^b	0.55
Ether extract	76.00	75.15	74.29	73.72	72.34	1.83
Nitrogen free extract	38.97	29.91	32.11	29.58	29.92	1.56

^{ab} = Means in the same row bearing different superscript differ significantly (p<0.05)

SEM = Standard error of mean

Table 2: Carcass measurements of rabbits fed diets containing varying levels dried okra leaves (*Abelmoschus esculentus*)

Levels of inclusion of okra dried leaves (%)							
(ODL)							
Parameters	0.00	2.50	5.00	7.50	10.00	SEM	P Values
Live weight (g/rabbit)	1583.33	1900.10	1800.78	1700.50	1580.33	22.88	0.706
Carcass weight (g/rabbit)	1150.33	1450.33	1300.67	1250.67	1100.00	19.72	0.880
Dressing percentage (%)	72.65	76.33	73.63	72.23	69.61	1.00	0.252
Cut parts (%)							
Head	8.51	8.63	8.67	7.92	8.13	0.13	0.303
Neck	3.22 ^{ab}	3.91 ^a	2.98 ^{ab}	2.32 ^b	2.72 ^b	0.19	0.505
Loin	14.96	14.70	17.76	16.49	14.05	0.59	0.504
Hind limb	16.37	16.22	15.11	15.40	14.70	0.33	0.486

Fore limb	9.90	7.79	9.92	9.99	9.750	0.35	0.232
Tail	0.54	0.54	0.57	0.47	0.62	0.26	0.554
Chest	7.92 ^b	10.99 ^a	8.55 ^{ab}	7.43 ^b	8.82 ^{ab}	0.43	0.055
Back	7.24 ^a	6.33 ^{ab}	4.98 ^b	4.75 ^b	3.81 ^b	54.05	0.452
GIT	10.83 ^b	12.81 ^{ab}	11.05 ^b	12.57 ^{ab}	14.28 ^a	0.47	0.105
Organs (%)							
Liver	2.5	2.68	2.37	2.50	2.70	0.87	0.782
Kidney	0.84	0.79	0.77	0.76	0.73	0.31	0.899
Heart	0.25 ^{ab}	0.27 ^a	0.18 ^b	0.19 ^b	0.22 ^{ab}	0.11	0.022
Lungs	0.46 ^b	0.44 ^b	0.57 ^{ab}	0.47 ^{ab}	0.67 ^a	0.10	0.031

^{ab---} Means in the same row with different superscripts differ significant (P<0.05)

SEM = Standard error of means

GIT = Gastro-intestinal tract

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EXTENDED SPECTRUM BETA-LACTAMASE PRODUCING ENTEROBACTERIACEAE FROM CHICKEN MEAT AND ITS CUTTING SURFACES

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ABSTRACT

Extended-Spectrum Beta Lactamases (ESBLs) are plasmid-mediated lactamase enzymes that hydrolyze and cause resistance to third-generation cephalosporins and monobactams. This study isolated and identified Enterobacteriaceae ESBL producers from three categories of chicken meat and their cutting surfaces. A total of 53 meat samples and 106 swab samples from chopping tables and knife blades were obtained from selected markets in 16 local government areas in Lagos State. Phenotypic confirmation of ampicillin-cefotaxime resistant isolates as ESBL-producers was done using the double disk diffusion synergy test. Isolates were then identified using Oxoid Microbact Rapid biochemical kit. The study detected 9 (16.07%) ESBL-producers among the 56 isolates subjected to the confirmatory test. These isolates included *Providencia* species, *Escherichia coli*, *Proteus* species, *Morganella* species and *Klebsiella* species. Members of the Enterobacteriaceae have been implicated in the emergence and spread of ESBLs among food-producing animals and their processing environment, this study highlights that chicken meat and its cutting surfaces may spread ESBL bacteria, thereby creating significant public health risks.

Keywords

Extended-Spectrum Beta Lactamase (ESBL), Enterobacteriaceae, Antimicrobial Resistance, Chicken Meat, Cutting Surfaces

INTRODUCTION

Beta-lactamase is the collective name of enzymes that hydrolyze the beta lactam ring to inactivate beta lactam antibiotics. The term extended spectrum, highlights the potentials of Extended Spectrum Beta Lactamase (ESBL) producers to hydrolyze a wider group of beta lactam antimicrobials (Beninati *et al.*, 2015). Extended spectrum beta-lactamases are plasmid-mediated beta-lactamases with the capacity to hydrolyze beta lactams except carbapenems and cephamycins, they also confer resistance to several non- beta lactam antibiotics (Hackman *et al.*, 2013).

The family Enterobacteriaceae consists of Gram negative, rod shaped, non-spore forming facultative anaerobes that are normal bacterial flora of the intestinal tract of food-producing animals and humans (Ugwu *et al.*, 2015). Members of the Enterobacteriaceae such as, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Escherichia coli*, *Proteus mirabilis*, *Enterobacter cloacae*, *Serratia* species, *Morganella morganii*, *Shigella* species, *Citrobacter* species and *Salmonella* species have been confirmed as ESBL producers (Santos *et al.*, 2013).

This study isolated Enterobacteriaceae ESBL producers and determined their antimicrobial susceptibility from chicken meat and their contact surfaces during processing in some locations in Lagos State.

MATERIALS AND METHOD

One hundred and fifty-nine samples consisting of three categories of (freshly dressed (16), frozen (20) and (17) barbeque) chicken meat and swabs from cutting surfaces (chopping table surfaces (53) and (53) knife blades) were collected from local markets and frozen foods stores in 16 different Local Government Areas in Lagos state.

Each sample was pre enriched in Peptone Water. A loopful of the 24hrs pre enriched broth culture was inoculated on MacConkey agar supplemented with ampicillin (100mg/L) and incubated at 37°C for 24 hrs. Pure cultures of ampicillin resistant colonies generated were transferred to MacConkey agar supplemented with Cefotaxime (1mg/L) and incubated at 37°C for 24 hrs.

All ampicillin-cefotaxime resistant isolates were tested for phenotypic expression of beta lactamase using the double disc synergy test with Cefotaxime and cefpodoxime (Oxoid) on sterile Mueller-Hinton agar plates (Balogun *et al.*, 2020). Bacterial isolates were identified by cultural characteristics, Gram staining and biochemical tests using Microbact GNB 24E, Oxoid. Furthermore, antimicrobial susceptibility test was done with seventeen antibiotics using the Kirby Bauer method.

RESULTS AND DISCUSSION

A total of nine isolates out of 56 ampicillin-cefotaxime resistant isolates were found to be phenotypic ESBL producers. Enterobacteriaceae ESBL producers obtained in the study were *Providencia* species, *Escherichia coli*, *Morganella* species, *Proteus* species and *Klebsiella* species as shown in Table 1. These ESBL producers were isolated from chicken meat, chopping surfaces and knife blades. Thus, highlighting these surfaces as potential sources of contaminations. The contamination of raw poultry meat, its cutting surfaces and recontamination of cooked poultry meat with antimicrobial resistant bacteria such as ESBL producers is a potential risk to consumers and food handlers (Zogg *et al.*, 2016).

Antimicrobial susceptibility test showed that the ESBL producers obtained in this study were resistant to the beta lactam and cephalosporin but were susceptible to carbapenem as seen in Table 2. Also, they were found to be resistant to more than one class of the other antibiotics. Public health risks increase as these microorganisms are often resistant to more

than one antimicrobial and have the ability to form biofilms on surfaces of equipment and tools used in chicken processing. Thereby increasing health risks of consumers and handlers and also serve as reservoirs of pathogenic and spoilage microorganisms (Serenó *et al.*, 2016).

Table 1: Extended Spectrum Beta Lactamase Producers in Chicken Meat and Processing Surfaces

Sample Category	Ampicillin Resistant Isolates N(%)	Cefotaxime Resistant Isolates N(%)	ESBL Producers N(%)	ESBL Isolates
CHICKEN MEAT				
Freshly Processed Live Chicken Meat	24(30.76)	7(35)	1 (11.11)	<i>Providencia</i> species
Frozen Chicken Meat	27(34.62)	5(25)	1 (11.11)	<i>Escherichia coli</i>
Barbeque Chicken Meat	27(34.62)	8(40)	1 (11.11)	<i>Proteus</i> species
TABLE SURFACES				
Freshly Processed Live Chicken	24(48.98)	5(41.67)	2 (22.22)	<i>Escherichia coli</i> <i>Providencia</i> species
Frozen Chicken	10(20.41)	6(12)	1 (11.11)	<i>Escherichia coli</i>
Barbeque Chicken	15(30.61)	1(8.33)	0 (0)	Nil
KNIFE BLADES				
Freshly Processed Live Chicken	9(22.5)	5(20.83)	1 (11.11)	<i>Morganella</i> species
Frozen Chicken	17(42.5)	11(45.83)	1 (11.11)	<i>Klebsiella</i> species
Barbeque Chicken	14(35)	8(33.33)	1 (11.11)	<i>Klebsiella</i> species

Table 2: Antimicrobial Resistance of ESBL Producers in Chicken Meat and Processing Areas In Lagos

Antimicrobial Agent	Number (%) Resistant
Ampicillin	9 (100)
Amoxycillin	9 (100)
Cefpodoxime	9 (100)
Cefotaxime	9 (100)
Cephalotin	8(88.88)
Cefuroxime	9 (100)
Cefoxitin	9 (100)
Cefepime	9 (100)
Ceftazidime	9 (100)
Gentamicin	3 (33.33)
Streptomycin	8(88.88)
Tetracycline	5(55.55)
Chloramphenicol	3 (33.33)
Ciprofloxacin	2 (22.22)
Nalixidic acid	5 (5.55)
Sulphamethoxazole/Trimethoprim	4 (44.44)
Imipenem	0(0)

CONCLUSION

Chicken meat, its chopping surfaces and blades are potential sources of ESBL producing *Providencia* species, *Escherichia coli*, *Morganella* species, *Proteus* species and *Klebsiella* species. All of these Enterobacteriaceae are opportunistic pathogens with significant public health risks.

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INCIDENCE OF MULTI-DRUG RESISTANT PATHOGENS IN VENDED LOCAL DAIRY FOODS IN ABUJA, NIGERIA

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Abstract

A significant vehicle of transmitting pathogens is raw unpasteurized milk. Nono is a locally fermented milk product obtained from unrefined cow milk. Its consumption can cause foodborne illness as it is a source of spoilage bacteria containing transferrable antimicrobial resistance genes. The emergence of resistance to antibiotics has become worrisome for health practitioners. The need to assess the locally fermented dairy products among consumers in, Abuja, thus becomes necessary. This study was conducted to evaluate the prevalence of multidrug resistant bacteria in some fermented dairy product in parts of Abuja. Samples of *nono*, were collected and analyzed for the presence of pathogens using standard microbiological techniques. Serial dilutions were made with appropriate dilutions plated on selective media, and incubated at 37°C for 24 hours. Discrete colonies were identified using morphological and biochemical techniques. Results showed the presence of *Bacillus subtilis*, *Shigella* specie, *Salmonella* specie., *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas* specie. and *Serratia* specie. Further findings showed that, *Shigella* specie., *Staphylococcus aureus* and *E. Coli* exhibited resistance to one or more antibiotics as follows; *Staphylococcus aureus* (Tetracycline, Erythromycin Chloramphenicol), *E. coli* (Tetracycline, Gentamycin) and *Shigella* specie (Tetracycline, Ciprofloxacin, Chloramphenicol). These findings depicted the gross contamination of nono with microorganisms of public health importance.

Keywords: *Pathogens, Toxins, Food, Nono, Abuja and Resistance*

Introduction

One of the major essential needs of man according to Haugen in (2012) is food especially one that is wholesome. Consumers are currently more interested in the safety and beneficial health effects of the foods they consume rather than the urge to eat; reason why there is a tilt towards consumption of wholesome functional food products that offers beneficial effects when consumed. It follows therefore that food safety is an important issue that affects all classes of people world over. Nono is an opaque, white to milky, spontaneously fermented milk (yoghurt-like) product produced in Nigeria and other parts of West Africa including Ghana, Burkina Faso (Owusu-Kwarteng *et al.*, 2010). The main source of nono is cow milk which differentiates it from other African fermented milk products where other animal milk such as goats, sheep, and camels are utilized. Historically, the major traditional processing steps of nono involves pouring fresh cow milk into containers containing previous leftover of the old product called 'ferments', which act to initiate the new, fresh batch of fermentation and then allowing it to ferment for a day or two at ambient temperature (Israel *et al.*, 2018). The product

thus produced has a yoghurt-like mild to sharp acid taste depending on how long it is allowed to ferment. This procedure however, results in an inconsistent product in terms of the quality and quantities of the microorganisms involved in the fermentation capable of affecting the safety and security of the process as well as the product produced. High prevalence of pathogens like Shiga toxin producing *Escherichia coli* (STEC) has emerged as a group of highly pathogenic strains characterized by the production of one or more Shiga toxins. Also, *Bacillus cereus* are of particular concern in food safety and public health due of their capacity to cause diseases in humans through the production of various forms of enterotoxins and emetic toxins (Shamloo *et al.*, 2019). Antibiotic resistance is a form of drug resistance whereby some (or, less commonly,) all sub-populations of a microorganism, usually bacterial species, are able to survive after exposure to one or more antibiotics; pathogens resistant to multiple antibiotics are considered multidrug resistant (MDR). This study was therefore carried out to identify the microorganisms of public health importance associated with the consumption of *nono* in Abuja metropolis particularly the occurrence of multi-drug resistant pathogenic strains hoping that the results generated will guide consumers, researchers, and policy makers as to the negative health impact of the consumption of such foods thereby offering and/or seeking ways to nip it in the bud.

Methods and Methodology

Study Area and Sampling

This present research was carried out in Lugbe (LB), Karu (KR), Kuje (KJ), Zuba (ZB) and Bwari (BR) Area Councils of the Federal Capital Territory (FCT), in Abuja being the areas that makes up the Federal capital of Nigeria. Thirty-Two (32) *nono* samples were randomly purchased from the study areas and collected in sterile bottles which were immediately transported in iced packs to the microbiological laboratory for analysis (Akabanda *et al.*, 2010).

Isolation of Bacteria

To isolate the bacteria of interest, the protocol of Akabanda *et al.* (2010) was used. Total aerobic count was carried out using standard plate count method. With a sterile pipette, 1 mL from the respective samples was transferred aseptically into 9 mL normal saline to make a ten-fold serial dilution. Afterwards, 1 mL of the appropriate dilutions (10^{-3} - 10^{-5}) were pipetted and poured correspondingly into triplicate of appropriately labeled petri-dishes. The previously autoclaved and cooled nutrient agar and selective media (Sigma-Aldrich company, USA), (15 mL) at 45°C was then carefully pour-plated onto the sample and swirled gently for proper mixing. The same was done for other samples and were all incubated at 37°C for 24 h. Discrete colonies obtained were counted using a colony counter (Sigma-Aldrich company, USA), the cellular

morphology was viewed under a light microscope while Gram's staining to differentiate them into either Gram ~~+~~ or ~~-~~ positive or negative was further carried out.

Selective Culturing and Identification of Isolates

After the preliminary Gram stain reaction, the resulting isolates of interest were subjected to further identification by streaking on selective media. Mannitol Salt Agar (MSA) was used for isolation of *Staphylococcus aureus*, Cetrimide agar for isolation of *Pseudomonas species*, Eosin Methylene Blue (EMB) agar for *E. coli*, *Salmonella shigella* Agar (SSA) for *Salmonella* species and MacConkey agar (MAC) for isolation of other *Enterobacteriaceae* present in the milk sample. On MSA, colonies that appeared yellowish were presumptively identified as *Staphylococci* while greenish colonies on cetrimide agar were identified as *Pseudomonas* species. Colonies that produced greenish metallic sheen on EMB were presumptively regarded as *E. coli* while colourless colonies with black spot on SSA were identified as *Salmonella* species. Based on lactose fermentation properties *Enterobacteriaceae* were isolated on MAC agar. All the presumptively identified organisms were sub-cultured on nutrient agar slant, incubated at 37°C for 24 h and stored in refrigerator at 4°C for further tests (Yeshambelet *et al.*, 2021).

Biochemical Tests

Using the modified method of Mudasingh *et al.*, (2019), biochemical tests like catalase, sugar fermentation, indole, oxidase, coagulase, citrate utilization, Methyl Red, Voges-Proskauer, triple sugar iron (TSI) and H₂S production to identify the isolated organisms were carried out.

Antibiotic Susceptibility Test

The susceptibility of the isolates to selected antibiotics was performed using the agar disk diffusion method with some modifications. Sterile swab was used to spread the bacteria suspension uniformly on the surface of sterile MRS agar. The antibiotics; tetracycline (30 µg), erythromycin (15 µg), chloramphenicol (30 µg), gentamicin (10 µg), ciprofloxacin (5 µg), cephalotin (30 µg), cotrimoxazole (25 µg), ceftriaxone (30 µg), amoxicillin (10 µg). The set-up was incubated for 24 hours at 37°C. After the incubation time, the various zones of inhibitions were recorded and used to prepare data of either resistance or susceptibility according to the Clinical Laboratory Standard Institute (CLSI, 2016).

Table 1: Biochemical Tests and Identification of Isolates

Isolate	Gram	TSI	MR	VP	Indole	Citrate	Catalase	Urease
<i>B. subtilis</i>	+	+	-	+	-	+	+	-
<i>Shigella</i> sp.	-	+	-	-	+	-	-	-
<i>Salmonella</i> sp.	-	+	+	-	+	+	+	-
<i>S. aureus</i>	+	+	+	+	-	+	+	+
<i>E. coli</i>	+	+	-	+	-	+	+	+
<i>Pseudomonas</i> sp.	-	-	-	+	+	+	+	+
<i>Serratia</i> sp.	-	+	-	+	-	+	-	-

Key: + = Positive; - = Negative

Table 2: The Antibiotic Susceptibility Pattern of Isolated Pathogens

Isolate	Susceptibility	Multi-Drug Status
<i>Bacillus subtilis</i>	+	-
<i>Shigella</i> sp.	-	2
<i>Salmonella</i> sp.	-	-
<i>Staphylococcus aureus</i>	-	3
<i>Escherichia coli</i>	-	2
<i>Pseudomonas</i> sp.	+	-
<i>Serratia</i> sp.	+	+

+ = Susceptible; - = Resistant

Results and Discussion

The bacteria obtained from the different locations namely Lugbe (LB), Karu (KR), Kuje (KJ), Zuba(ZB) and Bwari (BR) ranged from 6.0×10^5 - 11.4×10^8 , 2.3×10^6 - 3.6×10^8 , 2.9×10^5 - 5.3×10^8 , 4.0×10^6 - 2.6×10^9 and 24.0×10^6 - 12.8×10^8 Colony Forming Units per milliliter (CFU) mL⁻¹ respectively and this shows that the products (nono) were grossly contaminated with bacteria of public health concern which could result from low level or lack of maintenance of basic hygiene practices during the processing of the products (Akabanda *et al.* 2010).

In the same vein, out of the organisms, *Shigella sp.*, *Staphylococcus aureus* and *E. coli* exhibited resistance to one or more antibiotics in the pattern; *Staphylococcus aureus* (Tetracycline, Erythromycin Chloramphenicol), *E. coli* (tetracycline and gentamycin) and *Shigella sp.* (tetracycline and chloramphenicol) depicting that these sets of organisms possess antibiotic genes required to offer resistance to the antibiotics. This is as shown in Table 2.

The results obtained from the bacteriological analysis of *nono* samples sold in the selected locations showed that the products (*nono*) were grossly contaminated with bacteria of public health concern. These high-level bacterial counts in the *nono* samples could be as a result of low level or lack of maintenance of basic hygiene practices during the processing of the product (Akabanda *et al.* 2010). Several reports have shown that lack of proper sanitation and hygiene might be another factor for the high bacteria count (Oluwadara *et al.*, 2018). The presence of Gram-negative organisms such as *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Serratia* spp. and *Pseudomonas* sp. in this study is an indication of possible faecal contamination through water used in milk production, raw materials or storage environment. Although most people recover even without medications, it becomes a health risk where the organisms are antibiotic resistant because the genes for stable resistances could be horizontally transferred to other more pathogenic bacteria thereby making them more difficult to control with antibiotics (Friedman *et al.*, 2016).

Recommendations

The findings of this research work, notably the prevalence of the pathogenic organisms suggest the need for intervention in the safety of the milk product *nono* along the dairy value chain. Policy makers may then use these findings as an input to make intervention measures that will safeguard the public from potential risks. It is strongly recommended further that there should be a multi-sectorial approach geared towards sensitizing the public on the abuse, misuse and/or overuse of antibiotics which has been identified as the main agent responsible for the menace of multi drug resistant pathogens.

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EFFECT OF STORAGE ON THE pH AND TOTAL TITATABLE ACIDITY OF PROBIOTIC YOGHURT SUPPLEMENTED WITH FERMENTED MILLET BRAN AND DATE POWDER

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ABSTRACT

The study evaluated the effect of storage on the pH and total titratable acidity of yoghurt supplemented with fermented millet bran and date powder. Yoghurt was produced through optimization of some processing variables viz; skim milk powder: 11-15% of solid content in the preparation, fermented millet bran (FMB): 1-3% of solid content and date powder (DP): 6-10% of the solid content using Box Behnken Tool of Response Surface Methodology (RSM). The pH and titratable acidity of the yogurt samples, which were stored in a refrigerator (temperature: 4°C) over a period of three weeks, were determined on week 0, and at 1 week interval for 3 weeks. The result showed decrease and increase in pH and TTA, respectively, with storage period. This could be an indication of sustenance of viability of probiotic activities due to the added FMB and DP.

Keywords: Yoghurt, date powder, fermented millet bran, storage.

INTRODUCTION

The consumption of fermented dairy products, especially yoghurts, has increased markedly over the years (Zareet *et al.* 2011). Yogurt is a milk protein network aggregated through isoelectric precipitation by lactic acid bacteria. Lactic acid bacteria are a group of bacteria used to produce lactic acid from lactose during fermentation (Sun-Waterhouse *et al.* 2013). Examples include *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Lactic acid bacteria are in the class of probiotic microorganisms. Probiotics microorganisms are defined as live microorganisms that when administered in sufficient amounts, provide health benefits on the host (Hill *et al.* 2014). Yoghurt is a suitable probiotic carrier because it has ideal organoleptic properties, provides essential nutrients and good compatibility (Lucatto *et al.*, 2020). The importance of probiotic bacteria and the problems associated with maintaining their quantity, viability and stability encourages researchers to continuously develop novel products. For impactful health benefits, a labelled probiotic product is expected to contain not less than 6 log CFU/g of probiotic bacteria at the point of consumption (Hill *et al.*, 2014). Maintaining the viability and stability of probiotic microorganisms is a challenge during storage and retail holding of most commercially available yoghurt. Therefore, the foremost concern in commercial yoghurt processing is maintaining the viability and stability of probiotic micro-organisms during storage and retail holding. Reports in the literature had shown that addition various cereal bran

(Demirciet *al.*, 2017) into yoghurt significantly enhanced the probiotic activities of yoghurt. Hence, our hypothesis was that incorporating fermented millet bran and date liquid syrup will improve the quality, viability and stability of probiotic in yogurt. The pH and total titratable acidity (TTA) are important to access the continuous viability of lactic acid bacteria in yoghurt. Therefore, the aim of this study was to determine the changes in pH and TTA of yoghurt samples supplemented with fermented millet bran and date (*Phoenix dactylifera*) powder during three weeks storage under refrigerated condition

MATERIALS AND METHODS

Sample collection:

Skimmed milk, Date and Pearl millet were purchased from Kure market, Minna, Niger State and transported to the Department of Food Science and Technology, Federal University of Technology, Minna.

Sample preparations and Optimization protocol:

The Pearl millet and the Date were sorted to remove the spoilt ones. The Pearl millet was milled in Attrition mill using the Attrition mill (Model SKU ha-mi-fa-1) to obtain the bran. The millet bran was defatted according to the method of Chu (2019) and fermented according to the method described by Katina *et al.* (2012) with minor modification. The fermented millet bran was oven dried days at 40°C. Then, it was blended and sieved with a 77mm sieve pores to obtain the fermented pearl millet bran powder (FMB). The date was washed, dried, deseeded and milled using the Attrition mill (Model SKU ha-mi-fa-1) to produce the date powder (DP). The FMB and DP were then packaged in an airtight Ziploc bag for further processing.

Probiotic yogurt was prepared according to the method described by Dermiciet *al* (2017).

Box Behnken tool of Response Surface Methodology was used for the formulation of different samples of yogurt. The tool employed generated 17 runs with 5 replications at center point. Variable factors were: fermented millet bran (FMB): 1-3% of total solid content; date powder (DP): 6-10% of the total solid content; and skimmed milk: 11-15% solid content. The milk and date powder were reconstituted with warm water (4L). The reconstituted milk and date powder were heated to 85°C for 20 minutes. Finely milled fermented millet bran of 1-3% was incorporated. Direct Vat Set (DVS) starter culture (Chi) of 1% freeze-dried was incorporated after cooling the reconstituted milk in a water bath to 42°C. Yogurt preparation without FMB and DP served as control. The preparations were incubated at 42°C until pH of 4.5-5.5 was achieved. At the end of the fermentation, samples were cooled, poured in 50 plastic bottles and stored at refrigerated temperature (4°C) for 3weeks.

Methods

The pH and Total titratable acidity of the yogurt samples were determined on the fresh samples and at seven days interval during the storage duration (week0, week1, week2 and week3).

Statistical analysis

Experiments were carried out in triplicates. The analysis of variance (ANOVA) in SPSS 20 environment, was used to determine the Mean, (reported as the mean $\pm$ standard deviation) and separated using Duncan Multiple Range Test (DMRT). $P < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Overview of the pH and total titratable acidity of the prepared yoghurt samples over the storage period is as presented in Table 1 and Table 2, respectively, below. The pH range of 4.46 to 6.00 (Table 1) observed for freshly prepared yogurts in this study was within acidic level reported by Demirciet *al.* 2017. Control sample had the highest pH (6.00), i.e., least acidic, all through the storage period. Generally, pH of the sample was decreasing progressively with storage period. Similar observation was reported by Prasannaet *al.* 2013.

The total titratable acidity (TTA) of the freshly prepared yoghurt samples ranged from 0.07 (control) to 0.64% The samples were generally increasing with storage period. Similar trend was reported by Mousavi *et al.* 2018. Two reasons may be adduced for the observed decrease in pH and increased TTA of stored yogurt samples: enhanced viability and stability of lactic acid bacteria; and continued action of fermentation microorganisms.

Table 1: The pH of yoghurt samples during the storage period

Run	FMB (%)	DP (%)	SMC (%)	Week0	Week1	Week2	Week3
1	3.00	8.00	11.00	5.02 $\pm$ 0.14bc	4.21 $\pm$ 0.05b	4.17 $\pm$ 0.05bcd	4.15 $\pm$ 0.06bc
2	1.00	8.00	15.00	4.88 $\pm$ 0.20bc	4.28 $\pm$ 0.10b	4.25 $\pm$ 0.10bcd	4.17 $\pm$ 0.09bc
3	2.00	6.00	11.00	5.36 $\pm$ 0.09b	4.48 $\pm$ 0.10b	4.45 $\pm$ 0.01bc	4.43 $\pm$ 0.04b
4	2.00	8.00	13.00	4.86 $\pm$ 0.10bc	4.23 $\pm$ 0.03b	3.92 $\pm$ 0.01d	3.90 $\pm$ 0.04c
5	2.00	8.00	13.00	4.54 $\pm$ 0.12bc	4.21 $\pm$ 0.14b	4.11 $\pm$ 0.04cd	4.08 $\pm$ 0.06bc
6	3.00	10.00	13.00	5.18 $\pm$ 0.24bc	4.37 $\pm$ 0.05b	4.34 $\pm$ 0.13bc	4.31 $\pm$ 0.10b
7	1.00	8.00	11.00	5.14 $\pm$ 0.03bc	4.58 $\pm$ 0.05b	4.59 $\pm$ 0.05b	4.42 $\pm$ 0.01b
8	2.00	8.00	13.00	5.03 $\pm$ 0.05bc	4.57 $\pm$ 0.08b	4.43 $\pm$ 0.10bc	4.28 $\pm$ 0.02b
9	2.00	10.00	11.00	5.02 $\pm$ 0.17bc	4.47 $\pm$ 0.09b	4.44 $\pm$ 0.07bc	4.35 $\pm$ 0.08b
10	2.00	6.00	15.00	4.51 $\pm$ 0.24c	4.43 $\pm$ 0.25b	4.37 $\pm$ 0.12bc	4.35 $\pm$ 0.12b
11	3.00	6.00	13.00	4.46 $\pm$ 0.10c	4.36 $\pm$ 0.08b	4.29 $\pm$ 0.02bc	4.30 $\pm$ 0.05b
12	1.00	10.00	13.00	4.46 $\pm$ 0.26c	4.32 $\pm$ 0.20b	4.27 $\pm$ 0.17bcd	4.25 $\pm$ 0.12b
13	3.00	8.00	15.00	5.07 $\pm$ 0.24bc	4.51 $\pm$ 0.16b	4.42 $\pm$ 0.13bc	4.40 $\pm$ 0.10b
14	1.00	6.00	13.00	4.62 $\pm$ 0.09bc	4.56 $\pm$ 0.03b	4.49 $\pm$ 0.01bc	4.44 $\pm$ 0.04b
15	2.00	8.00	13.00	4.89 $\pm$ 0.13bc	4.55 $\pm$ 0.08b	4.44 $\pm$ 0.05bc	4.40 $\pm$ 0.06b
16	2.00	10.00	15.00	4.88 $\pm$ 0.18bc	4.43 $\pm$ 0.11b	4.38 $\pm$ 0.09bc	4.35 $\pm$ 0.08b

17	2.00	8.00	13.00	4.66 ± 0.20bc	4.41 ± 0.14b	4.33 ± 0.11bc	4.33 ± 0.09b
18	0	0	15.00	6.00 ± 0.10a	5.62 ± 0.12a	5.37 ± 0.07a	5.09 ± 0.10a

FMB: fermented millet bran; DP: date powder; SMC: skimmed milk content; TTA: total titratable acidity (given as %lactic acid). Values represent means and standard deviation of triplicate determinations. Mean values with different superscript in a row are significantly ($p \leq 0.05$) different from each other.

Table 2: The titratable acidity of yoghurt samples during the storage period

Run	FMB (%)	DP (%)		SMC (%)	Week0	Week1	Week2	Week3
1	3.00	8.00		11.00	0.1100 ± 0.0000a	0.0800 ± 0.0400b	0.2000 ± 0.0000e	0.2200 ± 0.0000a
2	1.00	8.00		15.00	0.1000 ± 0.0000a	0.1267 ± 0.0033b	0.2300 ± 0.0000b	0.2433 ± 0.0033a
3	2.00	6.00		11.00	0.1100 ± 0.0000a	0.1167 ± 0.0067b	0.2100 ± 0.0000d	0.2300 ± 0.0000a
4	2.00	8.00		13.00	0.0933 ± 0.0033a	0.6500 ± 0.2750a	0.2000 ± 0.0000e	0.2300 ± 0.0000a
5	2.00	8.00		13.00	0.0867 ± 0.0033a	0.1100 ± 0.0100b	0.1433 ± 0.0033h	0.7200 ± 0.5400a
6	3.00	10.00		13.00	0.0933 ± 0.0033a	0.1300 ± 0.0000b	0.1800 ± 0.0000g	0.1900 ± 0.0000a
7	1.00	8.00		11.00	0.1233 ± 0.0033a	0.1400 ± 0.0000b	0.2300 ± 0.0000b	0.2400 ± 0.0000a
8	2.00	8.00		13.00	0.1333 ± 0.0033a	0.1400 ± 0.0000b	0.2300 ± 0.0000b	0.2600 ± 0.0000a
9	2.00	10.00		11.00	0.1133 ± 0.0033a	0.1267 ± 0.0067b	0.2333 ± 0.0033b	0.4267 ± 0.0033a
10	2.00	6.00		15.00	0.3633 ± 0.2683a	0.1167 ± 0.0033b	0.2100 ± 0.0000d	0.2267 ± 0.0033a
11	3.00	6.00		13.00	0.0900 ± 0.0000a	0.1200 ± 0.0000b	0.1800 ± 0.0000g	0.1900 ± 0.0000a
12	1.00	10.00		13.00	0.6433 ± 0.2767a	0.1133 ± 0.0067b	0.2000 ± 0.0000e	0.2067 ± 0.0033a
13	3.00	8.00		15.00	0.1267 ± 0.0033a	0.1100 ± 0.0100b	0.2200 ± 0.0000c	0.2367 ± 0.0033a
14	1.00	6.00		13.00	0.0900 ± 0.0000a	0.1267 ± 0.0033b	0.1900 ± 0.0000f	0.1800 ± 0.0000a
15	2.00	8.00		13.00	0.1100 ± 0.0000a	0.1267 ± 0.0033b	0.2200 ± 0.0000c	0.2567 ± 0.0067a
16	2.00	10.00		15.00	0.3767 ± 0.2867a	0.1300 ± 0.0100b	0.1900 ± 0.0000f	0.3033 ± 0.0033a
17	2.00	8.00		13.00	0.1400 ± 0.0000a	0.1467 ± 0.0033b	0.2900 ± 0.0000a	0.2033 ± 0.1017a
18	0	0		15.00	0.0800 ± 0.0000a	0.0700 ± 0.0000b	0.0800 ± 0.0000i	0.0700 ± 0.0058a

FMB: fermented millet bran; DP: date powder; SMC: skimmed milk content; TTA: total titratable acidity (given as %lactic acid). Values represent means and standard deviation of triplicate determinations. Mean values with different superscript in a row are significantly ($p \leq 0.05$) different from each other.

CONCLUSION

Probiotic yogurts are expected to be acidic. Maintaining this acidity over storage period is important. This could be an indication of continuous viability of the probiotic microorganisms in the yogurt preparation. Hence, it could be inferred, in this study, that the incorporation of

fermented millet bran and date powder into yogurt formulation stabilizes the probiotic activities of the yogurt as evidenced by the progressive reduction in pH and increment of TTA over the storage duration.

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PHYSICAL AND SENSORY PROPERTIES ON BEEF TREATED WITH EXTRACTS OF SOME COMMON FRUITS

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ABSTRACT

Beef palatability is attributed to its tenderness, juiciness and flavour. Fruits are known to contain enzymes which can break down proteins in beef and make it more tender. Extracts from common fruits such as papaya, pineapple, and orange can be used to tender meat and are used for this research. It was obtained from Wednesday Market in Dutsin Ma and were processed to obtain the juice and pulp. Four beef samples measuring (12 x 10 x 1.5) cm thickness each were separately marinated with the fruit extracts and labeled as Samples; B (papaya), C (pineapple) and D (orange) while Sample A; (control) was left untreated. All the beef samples were grilled and evaluated for physical and sensory quality attributes using standard methods. Results of physical parameters revealed that pH, water holding capacity and shear press values varied significantly ($p < 0.05$) from 5.88 to 6.67, 7.88 to 11.11 % and 3.27 to 8.73 kg/cm³ respectively. Sensory quality attributes showed significant improvements ($p < 0.05$) amongst treatments as Sample C was rated highest in tenderness and overall acceptability. This study therefore concludes that using fruit extracts to marinate beef, significantly improve the physical and sensory attributes of beef. Thus, it is recommended that the use of pineapple be optimized as Sample C was the most preferred by consumers.

Key words: Steak, Fruits, Tenderness, Juiciness, Acceptability

INTRODUCTION

Beef and beef products are valuable and perceived as high-quality foods because they contain dietary protein, vitamin B, minerals, such as zinc, iron, and phosphorus and essential fatty acids in high amounts (Djordjevic *et al.*, 2017). The demand for high-quality meat, and in particular red meat, is expected to increase with eating quality being the most important factor in the consumers' choice of meat (Thorslund *et al.*, 2016). Flavour, juiciness, and tenderness are the three main attributes which influence the sensory enjoyment of meat, among which meat tenderness is considered the most important determinant of consumer preferences (Aaslyng and Meinert, 2017; Picard and Gagaoua, 2017). Tenderness in meat is the ease perceived by the consumer, with which meat structure is disorganized during mastication and have the largest role in consumer purchasing decisions Morton *et al.* (2018) and Mullen *et al.* (2017). Other factors that affect tenderness of a piece of meat are the type of muscle, pre- and post-slaughter factors, and postmortem pH and temperature (Anderson *et al.*, 2012), chemical composition, structure and amount of connective tissues (collagen), generally depends on the species, age of the animal, state of nutrition, sex, and the specific muscle types. The chemical composition, structure and amount of connective tissue (collagen), generally

depends on the species, age of the animal, state of nutrition, sex, and the specific muscle types which also affect meat tenderness (Wheeler *et al.*, 2000;Bolumaret *al.*, 2013). In contrast, meat toughness is an undesirable attribute of palatable meat quality for consumers (Kempet *al.*, 2010).

The quality and tenderness of meat and meat products can be improved in several ways using physical and chemical treatments. Commercial tenderizers fall under the chemical method of tenderizing meat. However, proteolytic enzymes of plant origin such as papain, ficin and bromelain and acidic tenderizers such as acetic acid or vinegar, lactic acid and citric acids have been used to soften meat within a short time (Warriss, 2000), these have been approved as generally regarded as safe (GRAS) for use in the meat industry by the US Department of Agriculture (Ha *et al.*, 2012). Thus, the enzymes and acids soften meat by denaturing protein and by breaking down the collagen, muscle fibres and tissues that connect it (Rawdkuenet *al.*, 2013). The process can change the texture, aroma and flavour of meat and sensory evaluation of the final product is usually used to evaluate the changes that might have occurred during tenderization.

Tenderness has risen, as concerns for consumer acceptance of beef and the pursuit of a guaranteed tender product amidst the high cost of energy and prolong cooking time as most people in Nigeria have resort to the use of baking soda, scrap metals such as nails, spoons and analgesics to tenderize beef which leaves a bitter taste in the meat and also can be detrimental to the human body as it could lead to life threatening conditions such as kidney and liver damage, acute renal failure and cancer. Therefore, this work is poised to evaluate the quality of beef treated with extracts of fruits (papaya, pineapple and orange) by utilizing the enzymes papain and bromelain from papaya and pineapple respectively and citric acid from orange fruits which are generally regarded as safe to provide beef that has improved physical and sensory qualities thereby enhancing consumers' satisfaction. Thus, reduce cooking time, cost of energy and to expunge the use of analgesic, baking soda and metallic materials in tenderizing beef which if used will predispose beef eaters to life threatening health issues.

MATERIALS AND METHODS

Materials

Meat, oranges, papaya and pineapples were purchased from Wednesday market in Dutsin-Ma Local Government Area of Katsina State. The equipment used for this research was of analytical standard and were sourced from Food Science Laboratory, Federal University Dutsin-Ma.

Sample Preparation

Production of papaya paste, pineapple paste and orange juice

Ripe papaya was washed, peeled with a kitchen knife, sliced and the seeds were removed. The sliced pulp was chopped into cubes and blended in a blender (Kenwood 4500W) to produce

a paste. Pineapple fruit was washed, peeled with a kitchen knife, sliced into cubes and blended in a blender (Kenwood 4500W) to form a paste. Ripe oranges were washed, cut into halves and juice was expressed from the oranges using a juice extractor (Eurolux ELCJ-1600) and these paste and juice were used to marinate the beef.

Preparation of beef samples for steak

Beef purchased from the abattoir in Wednesday market was wash thoroughly with potable water, papaya paste, pineapple paste and orange juice were used to marinate the meat and then the marinated meat treatments were transferred into a cellophane container, sealed and allowed to stay for 1hr at room temperature for the enzymes and acid to act on the meat. The meat was then washed, salt (2g), pepper (4g) was sprinkled on the meat and then grilled in an oven at 200°C for 40 to 45 mins, to get the steak. The untreated beef served as the control.

Physical properties of beef

A simplified shear force protocol as described by Shackelford *et al.* (2001) was used to determine the shear press value. pH value was carried out with a pH-meter while the water holding capacity (WHC) was determined according to method used by Wardlaw (2003).

Sensory Analysis

The sensory analysis of steak produced was conducted at the Food laboratory of Federal University Dutsinma and performed by affective testing (Iwe, 2002). Thirty (30) students were selected to evaluate the grilled beef using a 9-point hedonic scale. Steak samples were presented in clean ceramic dishes with potable water for the judges to rinse their mouth in between evaluations. The judges evaluated the grilled beef for appearance, flavour, juiciness, tenderness, and general acceptability.

Statistical Analysis

The analysis of variance (ANOVA) was used to analyze all data using the statistical package for social sciences (SPSS) version 16 for windows. Mean separation was performed by Dunca's multiple comparison range test ($p \leq 0.05$).

RESULTS AND DISCUSSIONS

Physical Properties of Beef

Results of the physical properties of beef treated with different fruits are as presented in Table 1.1. Values for pH, water holding capacity and shear press value varied significantly ($p < 0.05$) from 5.88 to 6.67, 7.88 to 11.11 % and 3.27 to 8.73 kg/cm³ respectively. pH is a measure of the acid or alkaline level of a substance. The result of pH showed that the value for untreated beef sample was 6.67, while treatments with orange, papaya and pineapple were 6.48, 6.18 and 5.18 respectively. This indicates that treatments with these fruits extracts increased the acidity of the beef and pineapple treated beef had the least pH. Sourness is a property of an acid and

this was as expected as pineapple tends to be sour when compared papaya and orange juice thus providing beef with lesser pH value. The pH value in the meat product is highly important because it has a major influence on other physicochemical and quality properties such as WHC, tenderness, and juiciness. The pH range of all the beef samples were however within the range of medium acid foods and hence can be susceptible to spoilage by microbes.

Water Holding Capacity (WHC) for meat is defined as the ability of meat and meat products to bind or retain water (Pearce *et al.*, 2011). The result of water holding capacity revealed that pineapple treated beef had the highest value of 11.11, followed by papaya treated beef(9.45), then orange treated beef(7.98), while the control had the least value of 7.88. There was however no significant difference ($p < 0.05$) between the control sample and the orange treated sample. The increase in the WHC after treatment could be due to pH level of the fruits as reported by Goliet *al.* (2007) which might have broken the hydrogen bonds between proteins, thus reduce their intactness and make them permeable to water. However, during grilling, the muscle proteins denatured, leading to a decrease in their WHC and shrinkage of the protein network. The shrunk network exerted a mechanical force on the water between the fibers and this was in consonance to the reports of Vandersman (2007). Therefore treating meat with these fruits will be beneficial as it will perform favourably in food preparations such as sausage, meat pie and canned meat where water is a key component.

Beef tenderness has to do with the chewiness or the ease with which the teeth masticate the meat. Meat tenderness is the most important attribute that governs consumer acceptability, satisfaction, and recurrent purchasing trends and market value for meat and meat products (Grunert *et al.*, 2004; Mennecke *et al.*, 2007). Results for the shear press value showed that samples A, B, C and D were 8.73, 5.48, 5.03 and 3.27 respectively. The result revealed that pineapple, orange and papaya significantly ($p < 0.05$) tenderized the meat which led to the decline in the shear press values. This therefore implies that the meat toughness was not affected much by postmortem processing and handling practices, but by pretreatments as all treatments were gotten from the same source but however yielded different results as a result of the treatment with these fruit extracts. Similar reports by Chang *et al.* (2011) had also described pretreatment, cooking method and temperature to be the determinants of meat tenderness.

Table 1.1: Physical Properties of Treated and Untreated Beef Samples.

Treatments	pH	Water Holding Capacity (%)	Shear Press Value (kg/cm ³)
A	6.67±0.03 ^c	7.88±0.01 ^a	8.73±0.01 ^c
B	6.18±0.04 ^b	9.45±0.49 ^b	5.08±0.49 ^b
C	5.88±0.11 ^a	11.11±0.01 ^c	3.27±0.01 ^a
D	6.48±0.01 ^c	7.98±0.01 ^a	5.43±0.49 ^b

Values are means ± standard deviation of duplicate determinations. Values with the same superscript within the same column are not significantly different ($p > 0.05$).

Key; A = Untreated beef (Control), B = Beef treated with papaya, C = Beef treated with pineapple, D = Beef treated with orange.

Sensory Attributes

Results of the sensory quality attributes of grilled meat tenderized with fruits (papaya, pineapple and orange) extracts are as presented in Table 1.2, for appearance, flavour, juiciness, tenderness and general acceptability. Human accepts food on the basis of certain characteristics that he/she defines and perceives with his/her senses, hence the need for sensory quality attribute analysis. Results for appearance showed that the control was ranked as the best in appearance with mean value of 7.53 followed by samples D (7.47), B (7.07) and C (5.33). This could be attributed to the decrease in pH with a corresponding increase in water holding capacity caused by the treatments using these fruit extracts thus retaining more moisture within the meat and causing discolouration as explained by Goliet *al.* (2007). Flavour is a fundamental sensory attribute which refers to the sensations in the mouth and nostril as a result of rising of food or drink volatile compounds. Sample treated with papaya had the highest mean value of 7.20, sample D (orange treated) and sample C (pineapple treated) had 7.17 and 7.07 respectively, while sample A (untreated beef) had the least mean score of 5.43. There was however significant difference ($p < 0.05$) among samples. This was as expected and could be attributed to the flavour impacted by the fruits as fruits are known to possess sweet taste and aroma.

Juiciness shows the response of sense organs to the chewability and juiciness of food in the mouth. Samples B, C and D had a mean value of 6.53, 7.03 and 7.43 respectively with no significant differences, while the control (sample A), was significantly different ($p < 0.05$) from other samples with least mean value of 5.33. Thus the control was the least acceptable in term of juiciness. This can be attributed to the presence of fruits in the other treatments which impacted more desirable qualities to the meat during cooking. Tenderness refers to the ease

with which the teeth penetrate or masticate the beef. From this research, it was observed that sample C had the highest mean value of 7.37, followed by sample B with mean value of 6.53, then sample D with mean value of 6.20, and sample A with the least mean value of 5.43. Sample C was significantly different ($p < 0.05$) from the other samples, however, sample B and D were not significantly different ($p < 0.05$). It therefore showed that treatment of beef with the fruit extracts improved the tenderness of the beef and sample C was the most preferred in terms of tenderness. This is as expected as treatment with fruit extracts increased the pH of the beef, breakdown the hydrogen bonds in proteins and reduce their intactness, increase their water holding capacity thus making them more friable and/or chewable.

The results for general acceptability revealed that sample C had the highest score with a mean value of 7.80, while sample A had the least score of 5.50. There was however, significant difference ($p < 0.05$) between sample A and every other samples. This overall assessment score is perhaps influenced by the flavour, juiciness and tenderness impacted by the fruits and hence beef treated with pineapple was ranked highest and regarded as the consumers' most preferred.

Table 1.2: Sensory Quality Attributes of Treated and Untreated Beef Sample

Sample	Appearance	Flavour	Juiciness	Tenderness	General Acceptability
A	7.53 $\pm$ 1.17 ^b	5.43 $\pm$ 1.72 ^a	5.33 $\pm$ 1.69 ^a	5.43 $\pm$ 2.11 ^a	5.50 $\pm$ 1.01 ^a
B	7.07 $\pm$ 1.23 ^b	7.20 $\pm$ 1.00 ^b	6.93 $\pm$ 1.08 ^b	6.53 $\pm$ 1.22 ^b	7.27 $\pm$ 0.20 ^c
C	6.33 $\pm$ 1.63 ^a	7.07 $\pm$ 1.26 ^b	7.03 $\pm$ 1.19 ^b	7.37 $\pm$ 1.07 ^c	7.80 $\pm$ 0.40 ^d
D	7.47 $\pm$ 0.97 ^b	7.17 $\pm$ 1.21 ^b	7.43 $\pm$ 1.04 ^b	6.20 $\pm$ 1.71 ^{ab}	7.60 $\pm$ 0.14 ^b

Values are means $\pm$ standard deviation of duplicate determinations. Values with the same superscript within the same column are not significantly different ($p > 0.05$).

Key; A = Untreated beef (Control), B = Beef treated with papaya, C = Beef treated with pineapple, D = Beef treated with orange.

CONCLUSION

This study has shown that treating beef with fruit (papaya, pineapple, and orange) extracts significantly improved its physical properties as pH and shear press value decreased while water holding capacity increased. Sensory attribute evaluation also revealed that beef treated with pineapple was rated the best in terms of tenderness and over all acceptability. It is therefore concluded that the treatment of beef with juice and pulp extract of fruits (papaya, pineapple and orange) significantly improved the physical properties and consumers acceptability of beef. The use of pineapple extract to tenderize meat is therefore recommended to cut down energy cost and beef cooking time. Storability studies of beef treated with these fruit extracts will be required to complement the results of the findings from this study.

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PROXIMATE COMPOSITION AND COLOUR ATTRIBUTES OF CHEESE ANALOGUE FROM BLEND OF SOURSOP(*A. muricata*) AND COMMERCIAL MILK

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Abstract

Promoting the utilization of locally available protein-rich crops may reduce the problem of protein-energy malnutrition. The proximate composition and colour attributes of commercial milk with soursop cheese analogue were evaluated. The milk blends were prepared by substituting the commercial milk with soursop milk at different proportions of 0 %, 5 %, 10 %, 15 %, and 20 %. The colour attributes showed a significant difference among all the samples. The percentage cheese analogue fat decreased by increasing the level of soursop substitution; however, lightness increased. The cheese analogue produced with 5 and 10 % soursop milk had the highest protein content. Cheese analogue with inclusion of soursop milk blends could be a promising value-added product serving as an alternative protein source.

Keywords: Cheese analogue, Proximate, Colour, Soursop

Introduction

In the past few years, consumers have become more interested in products that offer benefits to health. The need for alternatives for cow's milk has stood out mainly because of pathological reasons and food practices such as vegetarianism and veganism. The strategy used by these individuals and the food industry has been the plant-based milk. Cheese analogues are homogenous cheese-like food that are processed through combination of dairy and/or non-dairy ingredients; using fat and/or protein sources that are not native to cow milk. Usually, selected milk ingredients are replaced with cheaper vegetable products and are processed to simulate natural cheese in flavour and texture (Masottiet *al.*, 2018).

Tropical fruits have been used to produce several products which have gained global importance over time owing to their characteristic exotic aroma and colour (Abboet *al.*, 2006). Soursop (*Annonamuricata* L.) is a tropical fruit belonging to the Annonaceae family with a characteristic unique aroma and flavour. It is an exotic fruit that is recognized for its very pleasant, sub-acid, aromatic and juicy flesh. The fruit is an important source of vitamins, minerals and dietary fibre. Soursop fruit is often eaten raw or occasionally extracted and consumed as fresh soursop juice; consequently, the fruit is grossly underutilized and unexploited. The processing and consumption of soursop is of increasing interest owing to the functional and beneficial claims from several quarters. However, commercial utilization of soursop products is uncommon.

So far, there is limited information on proximate composition and colour attributes of cheese analogue developed from soursop. Hence, the current study evaluated the proximate composition and colour properties of formulated local cheese analogues (*warankashi*).

Materials and Methods

Materials

Commercial milk treated by ultra-high treatment (UHT) in tetra packs was obtained from ShopRite supermarket, Lagos. The ripe Soursop fruits (*Annonamuricata* L) used for this study were purchased from Oyingbo market Lagos, while Sodom apple leaves were obtained from Medical Centre, Yaba College of Technology, Lagos, respectively.

Blend formulation and production of cheese analogue

Soursop drink was produced according to the modified method of Ndifeet *et al.* (2014). The portion of the sieved milk for *warankashi* production from soursop was measured (50mL). Cheese samples were produced using 100 mL as standard with formulation by partial substitution of commercial processed milk with soursop milk at varying proportions, to create a range of 95:5; 90:10; 85:15 and 80:20 (v/v).

The 100 % commercial *warankashi* was produced and used as control. The sodom apple leaves were used as a coagulant. 10 g of the pounded sodom apple leaf was added to each of the milk blends. The method of Balogun *et al.* (2016) with some modifications was used to produce the cheese analogue.

Proximate composition and colour attributes

The proximate composition of the cheese analogue samples produced was carried out according to AOAC (2015). The colour attribute of *warankashi* was determined according to the method described by (Feili *et al.*, 2013).

Experimental design and Statistical Analysis

SPSS 16.0 was used to statistically analyze the data obtained from the study. Results obtained were intricate determinations and were subjected to an analysis of variance to determine the significant differences among the samples, and the means were separated using the Duncan Multiple Range Test. A completely randomized research design was used.

RESULTS AND DISCUSSION

Proximate Composition of Cheese Produced from

The result of proximate composition of cheese produced from blends of soursop and commercial milk is presented in Table 1. The moisture content of the *warankashi* ranged between 54.89 to 60.91 %. There was a significant ($p < 0.05$) difference in moisture content between the samples in this study. As expected, the moisture content of all the samples was relatively high with the sample containing 10 % soursop milk having the lowest moisture. The variation in the moisture content of cheese prepared with formulations of different blends was probably due to the differences in the gel network within the cheese and the coagulating ability

of the coagulant. There is a significant difference ($p < 0.05$) in the fat content of cheese analogue.

A decrease was observed in fat as the inclusion of soursop increased suggesting that the fat content is dependent largely on the commercial milk. The ash content of 'warankashi' products varied significantly ($p < 0.05$) as the control sample had a value of 2.49 %. Thus, it can be deduced that increase in the percentage commercial milk leads to increase in the ash content. The main function of proteins is to form new tissue and maintain existing tissue. The protein content (14.67 - 15.72%) observed in this study surprisingly showed that higher values were observed in all the cheese with soursop milk inclusion, reflecting its potential usefulness in combating protein-energy malnutrition, especially in the rural communities of the developing countries. Awolu (2016) reported that high carbohydrate content is directly proportional to the energy content of the food product. Carbohydrate content of the *warankashi* ranged from 2.70 to 3.22%.

Table 1: Proximate composition of *warankashi* produced from milk and soursop

Sample	Moisture content (%)	Fat content (%)	Ash content (%)	Protein content (%)	Carbohydrate content (%)
A	56.63 $\pm$ 0.05 ^b	22.75 $\pm$ 0.03 ^e	2.49 $\pm$ 0.01 ^d	15.72 $\pm$ 0.03 ^c	3.20 $\pm$ 0.01 ^b
B	57.97 $\pm$ 0.02 ^c	21.89 $\pm$ 0.03 ^c	2.28 $\pm$ 0.03 ^b	15.72 $\pm$ 0.03 ^c	3.20 $\pm$ 0.01 ^b
C	54.89 $\pm$ 0.04 ^a	22.04 $\pm$ 0.04 ^d	2.40 $\pm$ 0.03 ^e	15.72 $\pm$ 0.03 ^c	3.20 $\pm$ 0.01 ^b
D	58.54 $\pm$ 0.04 ^d	20.86 $\pm$ 0.05 ^b	2.14 $\pm$ 0.02 ^a	15.24 $\pm$ 0.04 ^b	3.22 $\pm$ 0.10 ^b
E	60.91 $\pm$ 0.05 ^e	19.60 $\pm$ 0.04 ^a	2.12 $\pm$ 0.04 ^a	14.67 $\pm$ 0.03 ^a	2.70 $\pm$ 0.01 ^a

Data are mean values of triplicate determination $\pm$ standard deviation.

Mean values with the same letter within the same column are not significantly different ($p \leq 0.05$)

A: 100% milk, B: 95%: 5% (milk – soursop), C: 90% :10% (milk – soursop), D: 85%: 15% (milk – soursop) and E: 80%: 20% (milk – soursop).

Colour attributes of cheese analogue

Colour of cheese analogue is very important as it determines how the product appeals to customers and its acceptability. The lightness of the *warankashi* (Table 2) ranged between 40.18 in the control sample (100 % commercial milk) to 42.11 in sample with (85% milk and 15% soursop). It was observed that the sample containing soursop milk reflect more lightness when compared to the reference sample. The values of redness (a^*) ranged between 5.59 and 7.37, and it was observed that the sample containing more soursop inclusion had the least redness

value compared to the control sample (100%). There was significant difference ($p \leq 0.05$) between the cheese analogue samples.

The values of yellowness (b^*) ranged between 17.35 to 21.06 with control sample (100 % milk) having the highest mean score and sample with 80% milk and 20% soursop having the least mean score. Significant difference ($p \leq 0.05$) was observed between the samples. Generally, colour of cheese analogues is affected by milk composition, cheese manufacturing technique, additives and natural microfloral activities. The variation in colour observed between the products must be related to the use of tropical fruit such as soursop fat as a substitute for dairy cream, since the differences between them tended to increase with increase in the proportion of this substitution(Cunha et al.,2010).

Table 2: Colour attributes of *Warankashi* produced from milk and soursop

Sample	Lightness	Redness	Yellowness
A	40.18±0.03 ^a	7.06±0.04 ^c	21.06±0.09 ^d
B	41.17±0.13 ^b	6.20±0.04 ^b	19.63±0.03 ^b
C	41.38±0.14 ^b	7.03±0.01 ^c	20.19±0.11 ^c
D	42.11±0.48 ^c	7.37±0.11 ^d	19.50±0.21 ^b
E	41.57±0.52 ^{bc}	5.59±0.11 ^a	17.35±0.15 ^a

Data are mean values of triplicate determination $\pm$ standard deviation.

Mean values with the same letter within the same column are not significantly different ($p \leq 0.05$)

A: 100% milk, B: 95%: 5% (milk – soursop), C: 90% :10% (milk – soursop), D: 85%: 15% (milk – soursop) and E: 80%: 20% (milk – soursop).

Conclusion

‘*Warankashi*’ is an excellent source of protein, fats and minerals such as calcium, iron and phosphorus, vitamins and essential amino acids, thus making it an important food in the diet of both old and young. Due to its fat content, they are easily predisposed to spoilage leading to off flavour and odour. Soursop as a tropical fruit showed good potential for use in the formulation of a functional drink. The addition of soursop in different proportion to the *warankashi* decrease its fat content and increase the protein content of *warankashi* at the end of production.

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EVALUATION OF THE EFFECTS OF SALTING AND DRYING ON SOME BIOCHEMICAL PARAMETERS OF CAPE SNOEK (*Thyrsites atun*)

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Abstract

The effect of various salt concentrations (saturated, 20% w/w and unsalted), temperature (30 and 40 °C) and relative humidity (40 and 50%) on water activity, moisture loss and weight loss of snoek portions during salting and drying were investigated. Moisture loss was high in snoek portions treated with saturated salt concentration compared to those treated with 20% (w/w) during the salting process. Progressive moisture loss, weight loss and reduced water activity were observed for all treatments examined. Salting, temperature and relative humidity of the drying environment had a significant effect on water activity and moisture loss of snoek during drying. The unsalted snoek portions had significantly higher moisture loss, lower weight and higher water activity than either of the two salted groups (20% w/w and saturated). Salting prior to drying considerably influenced the salt content, final water activity and weight of snoek. This study shows that salting snoek portions before drying helped to obtain effective water activity for extended shelf life of the products.

Key words: Salting, Drying, Water activity, Moisture loss,

INTRODUCTION

Salting is one of the oldest methods for preserving perishable meats such as marine and freshwater fish species (Sobukola and Olatunde, 2011). It is also used to develop desired organoleptic qualities in the products. There are a number of different salting methods (brining, dry salting and pickling) which are used depending on the specific product and the desired outcome. Salting helps to lower water activity and moisture content consequently, preventing microbial growth and other biochemical reactions which can lead to spoilage, thereby, improving the shelf life of fish (Chaijan, 2011). Although the drying behaviour and final characteristics of fish is greatly influenced by salting (Sobukola and Olatunde, 2011),

salting alone is inadequate for extending the shelf life of salted fish, therefore, further processing methods such as drying are necessary. Drying like salting also achieves preservation of fish by reducing the water content and water activity of the products. This is achieved traditionally by exposing the fish to direct sunlight. This can take several days depending on the intensity of sunlight and the relative humidity of the environment. However, the use of different drying techniques such as vacuum freeze drying, solar and microwave drying have been developed to mitigate these problems and enable the drying process to be appropriately monitored and controlled resulting in consistently good quality fish products. Water activity is a useful indicator of the stability of dried food products and represents the energy state of water in a system. Food products with water activity < 0.6 are generally referred to as microbiologically safe where spoilage only occurs as a result of chemical activities (Aberoumand, 2010). Salting and drying can significantly affect meat quality, product yield and shelf life of fish (Sobukola and Olatunde, 2011).

However, only limited information is available on the effects of salting and drying on snoek meat quality.

Snoek (*Thyrsites atun*) belongs to the snake mackerel family (Gempylidae) and is known as Cape snoek in South Africa, barracouta in New Zealand and Australia and sierrain Chile. Snoek is a coastal pelagic fish found in the southern hemisphere. Adult snoek are long, thin and perch-like in colour and can grow up to 200 cm in length and 9 kg in weight. Given the socio-economic importance of the South African snoek fishery, the knowledge gap on salting and drying of snoek is considered substantial. Therefore, identifying and measuring parameters which indicate snoek quality such as spoilage is advantageous. This study aimed to evaluate the effect of salting and drying at different salt concentrations and drying conditions ($^{\circ}\text{C}$ and relative humidity), on moisture loss, water activity and the final salt content of snoek portions.

Materials and Methods Raw material and salting pre-treatment

Whole fresh snoek ($n = 54$) were purchased from a snoek wholesale outlet at Phillipi, Western Cape province, South Africa. All fish were gutted and washed with clean water and cut into two equal parts along the line of symmetry. Each half was further divided into 3 portions and weighed individually (with an average weight of $130.76 \pm 31.5\text{g}$). A group of 108 portions ($n = 18$ fish) were salted to saturation (8kg), 108 portions ($n = 18$ fish) were salted at 20% (w/w) and 108 portions ($n = 18$ fish) were unsalted (0%). Salting was carried out using the dry salting method. Saturated salting was done by burying the fish portions in excess coarse food grade salt avoiding salt to salt contact. The 20% salting was achieved by salting the snoek portions with salt equivalent to 20% of the weight. The dry salting procedure was carried out at 4°C for 24 hours as suggested by Gallart-Jornet *et al.* (2007). All the fish portions were taken out of the

salting medium for weight measurement every 3 hours (n = 8 sampling periods). The fish portions were blotted dry using ply sheets in order to remove excess moisture and salt from the surface before weighing. Post salting, the fish portions were rinsed with clean fresh water to remove excess salt and were placed on racks at 4°C for 3 hours to allow excess water to drain before being weighed again. Weight loss (%) after salting was calculated using the following equation: $\text{Initial weight} - \text{Final weight} \div \text{Initial weight} \times 100$

Fish water activity and moisture content of each fish portion were only examined at the beginning (time 0 hour) and end (time 24 hours) of the salting process.

Drying experiments

Fish drying was carried out for 72 hours using a convection dryer (AIRMASTER® 1200-25002, Reich, UK). The air damper controls the inlet and outlet of air while relative humidity (RH) is measured psychrometrically. The air velocity was averaged at 1.5 m s⁻¹. Each of the three groups (saturation, 20% and 0% salt) was each subdivided into three treatments where relative humidity (40 and 50% RH) and temperature (30 and 40°C) were altered. The fish portions were placed on the oven racks, skin down and sampling for each group (saturation, 20% and 0%) was done at random. Moisture loss was determined from the moisture content data using the following equation:

$$\frac{\text{Initial moisture content} - \text{Final moisture content}}{\text{initial moisture content}} \times 100$$

Physiochemical parameter analysis

Moisture content was measured using the AOAC method (934.01). (Labcon drier, 334510).

A Pawkit water activity meter (AquaLab Decagon devices Inc. Version: October 15, 2013 08:15:20), with accuracy of $\pm 0.02 a_w$, was used to measure water activity. Salt analysis was carried out using Mohr's method. All chemical analyses were conducted in duplicate.

Statistical analysis

Statistical analysis was conducted using SAS software (Version 9.3) for Windows. A General Linear Model procedure (GLM) was used for the factorial analysis of the data, incorporating salt concentration, temperature, relative humidity and their interactions in the model. Where significant differences were found, a Bonferroni test was used to determine pairwise comparisons.

Statistica 11 software was used to analyse weight loss between 20% salted and saturated salted samples during salting only (one-way ANOVA); where differences were

found a Bonferroni Post hoc test was used to identify where the differences were. The relationship between water activity and portion weight during drying was determined using a Pearson correlation using Statistica 11 software and the confidence interval was set at 95%.

Result and Discussion

Moisture content, water activity and weight loss of snoek portions during the salting process

Moisture content and muscle weight loss varied ($p < 0.05$) between the 20% and saturated salted portions subsequent to the salting process. The saturated salted portions lost significantly ($p < 0.05$) more weight than the fish portions salted at 20%. The average moisture content was 60% and 66%, while weight loss post salting was 17% and 8% for snoek portions salted to saturation and 20%, respectively. In addition, those portions salted to saturation had significantly lower ($p < 0.05$) water activity (average = 0.82) compared to the 20% salted portions (average = 0.88).

The addition and concentration of salt can considerably affect protein stability/denaturation and subsequently the water retention capacity, moisture loss and the weight of fish meat (Nguyen *et al.*, 2011). Such an effect was observed in this study where moisture loss increased and the water retention capacity and weight of fish decreased due to the addition of salt.

Numerous studies found similar relationships between salt and weight loss (dehydration) in fish (Thorarinsdottir *et al.*, 2011). Low moisture content and water activity during salting are both desirable traits of salting process for extending shelf life of fish.

Moisture loss and water activity (unsalted, 20% salted and salted to saturation) during drying

Moisture loss increased as the drying process proceeded for all the salt groups (0%, 20% and saturated) and treatments (30°C/40% RH, 40°C/40% RH and 40°C/50% RH). However, variation in moisture loss between treatments was observed at various sampling time points. At time 0 20% salted samples had 5.6% moisture loss while the saturated salted samples had 16.6%. Snoek portions salted at 20% and dried at 40°C/50% RH had moisture loss lower ($p < 0.05$) than the others within the group and from the saturated salted group while there was no difference ($p \geq 0.05$) within the saturated group which were higher ($p < 0.05$) than the 20% salted.

A factorial ANOVA assessed the variation between all treatments analyzed ($n=9$). Significant statistical differences ($p <$

Table1. Moisture loss, water activity and weight change (mean±standard deviation) of snook portion (salted to saturation, 20% salted and unsalted) during drying at different temperature and relative humidity over time (0-72 hours)

Time	Treatment (Temperature/Relative humidity, salt concentration)							
	30°C/40% RH,	40°C/40% RH,	40°C/50% RH, 0%	30°C/40% RH,	40°C/40% RH,	40°C/50% RH,	30°C/40% RH,	40°C/40% RH,
Moisture loss (%)								
0			9.3 ^a ±1.59	9.2 ^a ±1.23	5.6 ^a ±0.71	15.5 ^a ±2.05	17.2 ^a ±0.89	16.6 ^a ±0.96
12	13.3 ^a ±5.29	24.9 ^a ±7.85	19.1 ^{ab} ±2.53	16.6 ^{ab} ±1.59	22.5 ^a ±7.80	22.8 ^a ±2.71	20.8 ^{ab} ±3.34	18.4 ^{ab} ±3.65
24	30.3 ^{ab} ±2.56	39.1 ^a ±5.21	32.0 ^{ab} ±6.37	25.9 ^a ±3.26	26.6 ^{ab} ±0.98	34.1 ^{ab} ±9.36	25.3 ^a ±9.81	26.0 ^{ab} ±5.32
36	33.3 ^{abc} ±4.99	49.2 ^a ±6.47	45.1 ^{ab} ±9.40	30.8 ^{ad} ±5.64	32.9 ^{bc} ±3.74	35.8 ^{abc} ±4.75	38.5 ^{abc} ±9.47	30.1 ^{cd} ±5.53
48	38.8 ^{bcd} ±7.54	50.1 ^{ab} ±9.05	51.4 ^a ±4.91	31.9 ^{cd} ±4.75	38.9 ^{bcd} ±1.15	39.2 ^{abcd} ±5.22	44.6 ^{abc} ±8.04	35.9 ^{cd} ±5.70
60	44.2 ^{cd} ±4.78	57.7 ^a ±3.61	56.4 ^a ±7.81	36.9 ^{cd} ±5.81	41.9 ^{cd} ±1.92	43.1 ^{cd} ±3.77	48.2 ^{ab} ±4.51	40.5 ^{cd} ±5.79
72	47.8 ^{cd} ±1.98	59.2 ^a ±3.50	59.6 ^a ±6.30	38.3 ^{cd} ±5.07	40.1 ^{cd} ±6.00	46.3 ^{cd} ±5.04	46.7 ^a ±5.55	47.0 ^a ±2.91
Water activity								
0	0.9 ^a ±0.01	0.9 ^a ±0.02	0.9 ^a ±0.00	0.8 ^a ±0.01	0.8 ^a ±0.01 ^a	0.8 ^a ±0.01	0	0.9 ^a ±0.01
12	0.9 ^a ±0.01	0.9 ^a ±0.02	0.9 ^a ±0.01	0.8 ^a ±0.02	0.8 ^{bc} ±0.06	0.8 ^a ±0.00	0.7 ^a ±0.00	0.7 ^a ±0.02 ^a
24	0.9 ^a ±0.01	0.9 ^a ±0.03	0.9 ^a ±0.03	0.7 ^a ±0.03	0.8 ^a ±0.03	0.7 ^a ±0.06	0.7 ^a ±0.00	0.7 ^a ±0.01 ^b
36	0.9 ^a ±0.01	0.8 ^a ±0.09	0.9 ^a ±0.07	0.7 ^a ±0.01	0.7 ^a ±0.03	0.7 ^a ±0.00	0.7 ^a ±0.02	0.7 ^a ±0.01 ^c
48	0.9 ^a ±0.02	0.8 ^{ab} ±0.13	0.8 ^{ab} ±0.06	0.7 ^a ±0.01	0.7 ^a ±0.05	0.7 ^{bc} ±0.02	0.7 ^a ±0.07	0.7 ^{bc} ±0.04 ^{bc}
60	0.9 ^a ±0.03	0.7 ^{bc} ±0.08	0.7 ^{bc} ±0.13	0.7 ^{bc} ±0.01	0.7 ^{bc} ±0.01	0.7 ^{bc} ±0.02	0.6 ^a ±0.08	0.7 ^{bc} ±0.03 ^{bc}
72	0.8 ^a ±0.05	0.7 ^a ±0.07	0.7 ^a ±0.15	0.7 ^a ±0.01	0.7 ^a ±0.03	0.7 ^a ±0.04	0.6 ^a ±0.08	0.6 ^a ±0.04 ^b
12	0.9 ^a ±0.01	0.9 ^a ±0.02	0.9 ^a ±0.01	0.8 ^a ±0.02	0.8 ^{bc} ±0.06	0.8 ^a ±0.00	0.7 ^a ±0.00	0.7 ^a ±0.02 ^a
Weight change (g)								
0	154.2 ^{ab} ±47.31	135.2 ^{ab} ±4.32	156.7 ^{ab} ±1.70	121.6 ^a ±22.73	123.5 ^a ±8.34	118.3 ^a ±15.58	115.8 ^a ±20.94	168.1 ^{ab} ±27.60
12	112.0 ^{ab} ±28.61	69.0 ^{ab} ±34.95	109.6 ^{ab} ±6.54	115.7 ^{ab} ±40.91	87.4 ^{ab} ±4.13	92.2 ^{ab} ±20.83	106.0 ^{ab} ±40.48	131.3 ^{ab} ±20.04
24	64.8 ^{ab} ±25.58	47.3 ^a ±21.66	86.8 ^{ab} ±1.38	87.8 ^{ab} ±27.18	81.2 ^{ab} ±7.56	78.9 ^{ab} ±27.41	81.0 ^{ab} ±34.07	116.7 ^a ±40.83
36	75.1 ^{ab} ±24.36	56.5 ^a ±17.16	57.6 ^a ±29.35	95.0 ^{abc} ±31.35	86.8 ^{abc} ±6.95	94.5 ^{abc} ±29.10	82.9 ^{abc} ±27.16	116.8 ^{ab} ±53.09
48	77.5 ^{ab} ±35.16	53.4 ^a ±21.63	56.3 ^a ±14.69	93.9 ^{ab} ±35.60	76.7 ^a ±15.51	74.3 ^a ±9.16	75.2 ^a ±18.35	109.3 ^{ab} ±50.75

The effect of Salt*Temp-RH on moisture loss was significant at 36, 48 and 60 hours ($p < 0.001$). The interaction contribution was calculated for all significant interactions.

0.05) were observed between 20% salted portions dried at 40°C/50% RH and between the 20% salted treatments dried at 40°C/50% RH and the saturated treatments. However, no significant difference ($p \geq 0.05$) was observed between the three treatments which were salted to saturation. Although not consistently significant, the highest moisture loss was found in unsalted portions dried at 40°C/40% RH (time 12, 24, 36 and 60 hours) and 40°C/50% RH (48 and 72 hours). Concurrently, the lowest moisture loss was observed in the saturated portions (except for time 0, 12 and 24 hours). A summary of the ANOVA results is present in Table 1

The effect of temperature and relative humidity was significant ($p < 0.01$) over the drying period except at time 24 and 48 hours; where significant, the 40°C/40% RH treatment had the highest moisture loss. 30°C/40% RH was significantly ($p < 0.05$) higher than all the salted treatments at every time point except at time 0. and 12 and also

varied significantly between treatments within the same salt group at time 36, 60 and 72 hours. Simultaneously, a low but inconsistently significant water activity was observed in saturated portions dried at 30°C/40% RH throughout the experiment except at time 0. At the end of the experiment the average water activity was 0.64, 0.68 and 0.72 for saturated, 20% salted and unsalted snoek portions, respectively (Table 1).

Although moisture loss increased over the experimental drying period, which is desirable for extended shelf life of dried snoek, the rate of moisture loss for each treatment fluctuated substantially at each sampling point. The anatomical section analysed, size (volume to surface area ratio) of portion, contact with drying air, temperature, relative humidity and the salt concentration within the muscle of the snoek portions can all play a role in increased/reduced moisture loss in fish and could potentially explain the high variability observed (Guizani *et al.*, 2008). Although reduced weight and high moisture loss was observed for the unsalted snoek portions, the final water activity was higher than those of the salted snoek. This is an indication that salted snoek will be able to resist microbial attack and other chemical reactions that can occur at high water activity. High moisture loss generally reflects low water activity in both snoek, other fish species and shark fillets (Chaijan, 2011) dried under various conditions. This pattern between water activity and added salt content has been described for a number of other species such as dry salted tilapia (*Oreochromis niloticus*) (Chaijan, 2011), shark fillets, Tilapia (*Tilapia zilli*) (Ikranget *et al.*, 2014). The final water activity in the saturated treatment dried at 30°C/40% RH, and 40°C/40% RH (0.6) was adequate to prevent spoilage in the products as it was the same as the advised limit of 0.6 which is regarded as sufficient to prevent microbial growth (Aberoumand, 2010).

The effect of drying on weight of salted and unsalted snoek

A progressive decrease in portion weight was observed for all the groups and treatments as drying progressed from 0 to 72 hours. The unsalted portions dried at 40°C/40% RH had the lowest weight (excluding time 0) and saturated salt portions dried at 40°C/50% RH had the highest weight compared to the other treatments; however, these differences were not constantly significant. The weight of the fish portions at 72 hours were on average 47.6, 83.3 and 91.3 g for unsalted, 20% salted and the saturated salted snoek portions.

Salt content of salted dried snoek

The salt content of the salted snoek was 23.6% for portions salted to saturation and 12.8% for those salted at 20%. The overall lowest salt content (11.8%) was observed in snoek portions salted at 20% and dried at 40°C/40% RH while the highest salt content (27.4%) was found in portions salted to saturation and dried at 40°C/40% RH.

Significant variation was observed ($p < 0.05$) between the six salted variables at time 72 hours. In addition, portions dried at 40°C/40% RH had higher ($p < 0.05$) salt contents than the portions dried at 40°C/50% RH within the saturated group. The salt concentration of portions salted at 20% did not differ significantly ($p \geq 0.05$).

Hindrance to moisture loss due to crust formation may have resulted in low weight loss observed in the saturated salted snoek especially the saturated salted dried at 40°C/50% RH during drying and the portions of the fish sampled at the different time point (Random sampling). The low weight of the unsalted fish portions may also be due to high moisture loss observed during the drying process. Although, salting can hinder drying process it is desirable for development of organoleptic characteristics and prolonged storability of fish products.

The salt content of snoek salted at 20% salt concentration was below the recommended level for salted dried fish (15-25%) while that of the saturated salted snoek was above the recommended level (Wang *et al.*, 2011a). The result of this investigation is similar to the high salt content reported for dry salted African catfish (*Clarias gariepinus*) Sobukola and Olatunde, (2011). High salt content is desirable for extending shelf life of fish products but it must be done with caution as current trend in food processing requires the use of reduce salt content due to its health implication.

Conclusion

The result of this study shows that drying and salting procedures had significant effect on moisture loss, water activity and weight loss of snoek portion during salting and drying. This study suggests that salting snoek portions before drying helped to obtain effective water activity for extended shelf life of the products however, salting should not be above 20% to achieve low salt content. Salting of snoek at 20% and drying at 40°C/40% RH is suggested for good quality product with low salt content, low water activity and high product yield. Further studies are required to determine the effect of salt concentration on the nutritional composition of snoek, lipid oxidation and the microbial load during and after drying and its effect on the storage stability of snoek portions.

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SENSORY PROPERTIES AND FREE FATTY ACID CONTENT OF MEAT OF BROILER CHICKEN FED VARYING LEVELS OF KERATINASE-TREATED AND UNTREATED FEATHER MEAL DIETS.

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ABSTRACT

The effect of feather meal diet on sensory properties and free fatty acid of broiler meat was investigated. Broilers were fed with feed in which keratinase-treated and untreated feathermeal was used to replace groundnut as protein source. After slaughter, de-feathering and evisceration, the breast was used for analysis of free fatty acid (FFA) content and sensory properties. Results obtained for sensory attribute showed that use of feather meal diet had significant effect ($P < 0.05$) on the appearance and taste of broiler meat. Lower tenderness was recorded in meat of broiler fed diet containing 24% and 16% untreated feather meal diet and treated feather meal diet respectively. The FFA values were relatively low all through the period of storage with values between 0.34 and 0.73Mg KOH. The results showed that feather meal diet had significant ($P < 0.05$) effect on the FFA content of broiler meat and the effect was higher with keratinase-treated feather meal diet for the first three months. Results obtained show that feather meal diet can be included in the diet of broilers as a protein source up to 24% inclusion level.

Key words: Broilers, Feathermeal, Sensory, Free fatty acid

1.0 INTRODUCTION

The growing demand for poultry meat has led to an increased production of broiler chickens (FAO, 2010). In the year 2015 alone, global production of meat from poultry stood at 100.6 million tons and this figure is expected to hit 143.3 million tons by the year 2030 (Bruinsma, 2015). Feathers are byproducts obtained from the processing of poultry such as chicken, turkeys, ducks, quails, guinea fowl, geese etc. Nigeria is credited to have the highest population of chickens in Africa with a population of 180 million chickens (ASL2050, 2018). Similarly, FAO (2019) reported that 24 billion chickens were produced globally in the year 2018 and about 2.4 million tons of chicken feather were produced that same year. These huge quantities of poultry feather produced globally often constitute environmental pollution (Zhang *et. al.*, 2014).

The use of broiler feathers as protein source in broiler feeding have been reported to improve carcass characteristics and meat quality attributes of broilers (Ajayi and Iyayi, 2015; Ajayi and Akoma, 2017). Although there are no documented reports on the effect of keratinase-treated feather on broiler meat quality, the beneficial role of enzymes in feather meal was reported in the study by Ajayi and Akoma (2017).

This study is therefore, aimed at determining the effects of feather meal diet on the sensory properties and free fatty acid content of broilers meat.

2.0 MATERIALS AND METHODS

Broilers fed with feed containing varying levels (0%, 8%, 16%, 24%) keratinase treated and untreated feather meal as a source of protein (feather meal was used to replace groundnut) were slaughtered and de-feathered manually by hand after dipping in hot water (70-80°C). The internal organ (heart, intestine, liver, kidney, abdominal fat, gizzard, and intestine) was removed and primal cuts like head, neck, wing, thigh, breast meat back, and drumstick will be removed. The breast meat was used for sensory evaluation. The breast was cut into bite sizes and boiled for 10 minute with a pinch of salt. It was served to a 30-member, semi-trained panel consisting of students of the Department of Food Science and Technology, Federal University of Technology, Minna. The meat samples were scored using a 9-point hedonic scale where 1= dislike extremely and 9= like extremely. Bottled water was provided for panel members to rinse their mouths between samples. The sensory attributes scored were colour, juiciness, taste, tenderness, aroma, texture and overall acceptability.

Free fatty acid content of broiler meat sample was also determined using the breast portion of meat. The breast meat was packed in Ziploc bags and was stored at 4°C and analyzed on a monthly basis for six months. The free fatty acid contents were determined using the method of AOAC (2005).

3.0 RESULTS AND DISCUSSION

The sensory scores of meats of broilers fed treated and untreated feather meal diet are shown in Table 1. Results for juiciness and over all acceptability showed no significant difference ($P > 0.05$) between samples. However, significant difference ($P < 0.05$) was observed in the appearance, taste and tenderness of the meat samples. Scores obtained indicate that inclusion of feather meal in the diet enhance the appearance and taste of the meat samples with scores between 6.96-7.56 for appearance and 7.00-7.64 for taste compared with 6.76 and 6.80 for the control sample. As for tenderness, meat of broilers fed diets containing 24% UFMD and 16% TFMD recorded ($P < 0.05$) lower scores for tenderness compared with other meat samples. The difference observed may be as a result of differences in individual perception and level of acceptability. Ajayi and Akoma (2017). They may also be due to the presence and different level of volatiles derived from the keratin of feather.

The free fatty acid (FFA) contents of the meat samples are shown in Table 2. The FFA values were relatively low all through the period of storage with values between 0.34 and 0.73Mg KOH. The results showed that feather meal diet had significant ($P < 0.05$) effect on the FFA content of broiler meat and the effect was higher with keratinase-treated feather meal diet. The higher the level of the feather meal, the higher the FFA content and this was the trend for the first three months. After three months, the control sample and sample from broilers

8% and 16% UFMD recorded higher FFA content just like the samples from TFMD. Free fatty acids tend to accelerate hydro peroxidation leading to offensive taste and flavour.

TABLE 1: MEAN SENSORY SCORES OF BROILER MEAT DERIVED FROM BROILERS FED FEATHER MEAL DIETS

Parameter	Broiler Meat Samples						
	Control	(8%)UFMD	(16%) UFMD	(24%)UFMD	(8%)TFMD	(16%)TFMD	(24%)TFMD
Colour	7.24 ^a ±0.16	7.24 ^a ±0.17	7.32 ^a ±0.16	7.08 ^a ±0.19	7.36 ^a ±0.12	7.16 ^a ±0.17	7.20 ^a ±0.01
Juciness	6.92 ^a ±0.23	7.28 ^a ±0.21	7.08 ^a ±0.23	6.96 ^a ±0.16	7.36 ^a ±0.15	7.40 ^a ±0.17	7.36 ^a ±0.20
Appearance	6.76 ^c ±0.22	6.96 ^{bc} ±0.20	7.40 ^{ab} ±0.15	7.24 ^{abc} ±0.14	7.24 ^{abc} ±0.17	7.28 ^{abc} ±0.18	7.56 ^a ±0.17
Flavour	6.80 ^c ±0.22	7.52 ^{ab} ±0.14	7.56 ^{ab} ±0.15	7.00 ^{bc} ±0.21	7.36 ^{abc} ±0.19	7.56 ^{ab} ±0.17	7.64 ^a ±0.15
Aroma	7.24 ^a ±0.22	7.36 ^a ±0.17	7.60 ^a ±0.15	7.28 ^a ±0.22	7.32 ^a ±0.16	7.44 ^a ±0.18	7.28 ^a ±0.19
Tenderness	7.60 ^a ±0.21	7.64 ^a ±0.19	7.62 ^a ±0.17	7.40 ^b ±0.24	7.56 ^a ±0.15	7.48 ^b ±0.18	7.64 ^a ±0.15
OA	7.56 ^a ±0.20	7.64 ^a ±0.19	7.50 ^a ±0.14	7.32 ^a ±0.20	7.64 ^a ±0.19	7.76 ^a ±0.18	7.72 ^a ±0.14
Storage Period (Months)	Control (0%FMD)	8% UFMD	16% UFMD	24% UFMD	8% TFMD	16%TFMD	24%TFMD
0	0.37 ^d ±0.00	0.34 ^e ±0.00	0.35 ^e ±0.01	0.34 ^e ±0.01	0.41 ^c ±0.00	0.49 ^b ±0.02	0.66 ^a ±0.01
1	0.39 ^c ±0.00	0.34 ^d ±0.00	0.35 ^d ±0.01	0.34 ^d ±0.01	0.45 ^c ±0.01	0.45 ^b ±0.00	0.57 ^a ±0.01
2	0.40 ^{de} ±0.01	0.44 ^{cd} ±0.02	0.36 ^e ±0.01	0.39 ^e ±0.01	0.45 ^{bc} ±0.01	0.57 ^b ±0.01	0.65 ^a ±0.01
3	0.43 ^c ±0.01	0.49 ^b ±0.01	0.38 ^e ±0.01	0.39 ^e ±0.01	0.42 ^d ±0.01	0.50 ^b ±0.00	0.70 ^a ±0.01
4	0.49 ^{bc} ±0.01	0.54 ^b ±0.02	0.41 ^d ±0.01	0.44 ^d ±0.01	0.44 ^d ±0.01	0.54 ^b ±0.01	0.72 ^a ±0.00
5	0.59 ^{bc} ±0.01	0.63 ^b ±0.02	0.57 ^{cd} ±0.01	0.53 ^d ±0.01	0.60 ^{bc} ±0.01	0.64 ^b ±0.01	0.73 ^a ±0.01
6	0.57 ^{cd} ±0.01	0.65 ^b ±0.02	0.56 ^d ±0.01	0.55 ^d ±0.01	0.60 ^c ±0.01	0.64 ^b ±0.01	0.71 ^a ±0.01

Means in the same row with different superscripts are significantly different at (P<0.05).

UFMD = Untreated feather meal diet

TFMD = Treated feather meal diet

4.0 CONCLUSION

On the basis of sensory scores and free fatty acid contents, the results of this study show that poultry feather can be used as a protein source in broiler feed without any negative effect on broiler meat sensory properties as well as free fatty acid content of broiler meat during storage.

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EFFECT OF DRYING METHODS ON THE MINERAL PROFILE OF AFRICAN GIANT BURROWING CRICKET

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Abstract

The growing demand for food, occasioned by the worlds' rapidly increasing population has led the global food industry into exploring novel and affordable food sources. Edible insects are novel sources of high-quality nutrients for human consumption. This study investigates the effect of drying method on the mineral profile of African giant burrowing cricket. The cricket samples were dried using freeze drying, cabinet drying and oven drying methods. The mineral contents of the dried samples were determined, and the results obtained were subjected to statistical analysis using Analysis of Variance (ANOVA). The results revealed that the freeze-dried samples generally contain higher quantity of minerals while the oven dried samples generally had the least quantity of minerals. The result also revealed that among the minerals analysed, potassium is the most abundant in the samples while manganese is the least abundant. Drying method did not significantly affect the sodium content of the samples, while the cabinet dried samples had the highest calcium content but was not significantly higher than the freeze-dried samples. The study also showed that the zinc content of the freeze-dried samples was significantly higher than the cabinet dried samples but was not significantly higher than the oven dried samples. It was concluded that drying method generally affected the value of minerals in the samples under study.

Key words: Cricket, Insect, Mineral profile, Entomophagy, Drying methods.

1.0 Introduction

As the world population continues to grow from about 8 billion in year 2021 to an estimated 11 billion in year 2100 (United Nations, 2022), the global demand for food continues to increase. Several approaches have been proposed in order to respond to the growing demand for food, one of which is the use of novel and affordable food sources. Entomophagy is one of the most promising novel and affordable options, providing high quality nutrients for human consumption. Entomophagy is defined as the practice of eating insects as food source, either as whole processed insects or nutrients extracted from insect as functional ingredients and processed into modern food systems. In addition to quality protein, insects have also been reported to be good sources of polyunsaturated fatty acids and micro-nutrient elements such as calcium, potassium, magnesium, phosphorus, Sodium, Iron, zinc, manganese, and copper as well as vitamins like folic acid, pantothenic acid, riboflavin, folic acid and biotin, which are the most deficient nutrients in humans (Magara *et al.*, 2021; Payne *et al.*, 2016; Rumpold and Schlüter, 2013). Although the western world may have considered entomophagy as dirty, disgusting, and dangerous in the past couple of decades (Looy and Wood, 2006), insects have however played an important role in the history of human nutrition in Africa and Asia. For

instance, countries such as China have been reported to consume 324 species of insects, India and Thailand have been reported to consume 255 and 164 species, respectively while Africa consumes over 500 species (Magara *et al.*, 2021).

The generally consumed insects are the orders Orthoptera, Hymenoptera, Coleoptera and Lepidoptera respectively. Among the Orthopterans, crickets stand as the most consumed with *Brachytrupes membranaceus*, *Acheta domesticus*, *Gryllus similis*, *Gryllus bimaculatus* and *Gryllotalpa orientalis* as the most reported species in literature. Edible crickets are excellent sources of proteins, lipids, carbohydrates, mineral salts, and vitamins (Magara *et al.*, 2021), however, its nutritional composition varies across the different species, and have also been reported to vary with the method in which the crickets are processed (Musundire *et al.*, 2014). While various processing methods such as drying, cooking, smoking, blanching, stewing, deep-frying, roasting, and toasting have been reported to be used in processing of crickets depending on the species used and the final product to be developed, there remains a scientific knowledge gap on the effect of these processing methods on specific nutritional composition of particular species of cricket. Since most studies focus on physicochemical characterization and profiling, while providing few or no details on the specific processing conditions applied, it is difficult to compare the results obtained, even for the same species. The goal of this study is to examine the effect of drying methods on the mineral profile of African giant burrowing cricket

2.0 Materials and methods

2.1 Sample Preparation

The samples used in this study were male crickets previously identified to be African Giant Burrowing Crickets (Tobacco Cricket) *Brachytrupes membranaceus membranaceus* Dury. The male crickets were obtained from farmlands across Falokun Oja, in Ifelodun Local Government Area of Kwara State, Nigeria. The live crickets obtained were washed to remove sand and dirt, they were then degutted and defeathered for further processing. In order to study the effect of drying methods on the chemical qualities of the crickets, the degutted and defeathered crickets were subjected to three different drying methods: Freeze drying, cabinet drying and oven drying. A laboratory manifold freeze dryer, model number: 700201000 Labconco freeZone 1 litre capacity, available at the Central Research Laboratory of the University of Ilorin, Nigeria was used for drying of the crickets. The cricket samples were pre-frozen in a laboratory blast freezer at a eutectic temperature of -49°C for 28 hours. The pre-frozen crickets were then quickly attached to the manifold for drying, while the collector temperature was set to -70°C and the vacuum pump was at 0.0025 mbar. The cricket samples were allowed to dry for 17 hours. The freeze-dried cricket samples were then removed from the flasks and stored in a domestic freezer for analysis. A laboratory cabinet and oven dryer available at the National centre for Agricultural Mechanization (NCAM) Ilorin was used for this study. Drying using cabinet and oven dryer was done at temperature of 45±5°C. The choice of 45°C was based on preliminary investigation which showed that drying could not be attained at a temperature below 45°C. The dried samples were then milled, sieved and packed in a laboratory refrigerator at 4°C for analysis.

2.2 Mineral Analysis

The mineral profile of the samples was determined using Flame Atomic Absorption Spectrophotometer (FAAS) as described by AOAC (2010) method number 985.35. Buck scientific Atomic Absorption Spectrophotometer (AAS) model 210 was used to determine the minerals in milled samples while Flame Photometer was used to determine potassium and sodium. Phosphorus was however determined using colorimetric method described by AOAC (2010). The result obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS)

3.0 Results and Discussion

The result of the mineral profile is presented in Table 1. From the table, it could be observed that the results were generally significantly different from each other at $p \leq 0.05$. Generally, the freeze-dried samples contained higher quantity of minerals while the oven dried samples generally had the least quantity of minerals as revealed by the results. The result also revealed that among the minerals analysed, Potassium is the most abundant in the samples while Manganese is the least abundant. The highest mineral content of the samples under study (Potassium) was found in the freeze-dried samples which had a value of 0.81g/100g while the lowest mineral content is the Manganese content of the oven dried samples which had a value of 0.0008g/100g.

The cabinet dried samples had the highest calcium content of 0.027g/100g which was not significantly different from the freeze-dried samples which had a value of 0.023g/100g but was significantly different from the oven dried samples which had the least value of 0.009g/100g. This implies that drying method had significant effect on the value of calcium in the samples, especially in the oven dried samples. This may have resulted from the unequal distribution of heat during the oven drying, as the oven had no blower to evenly distribute the heat within the chamber and drive out moisture evenly from the sample matrix. Although oven dried insect products have been reported to be nutritionally comparable with freeze-dried products (Melgar-Lalanne, *et al.*, 2019), some of the calcium within the exoskeleton of the samples may have been lost due to the uneven drying. The value obtained are similar to values reported by Magara *et al.*, 2021 for *BrachytrupesMembranaceus*, *Brachytrypesspp* and *Acheta domesticus*. According to the authors, *Brachytrupesmembranaceus* contained 0.00921g/g while *Brachytrypesspp.* and *Acheta domesticus* contained 0.00498g/g and 0.17107g/g of calcium.

The Table also showed that there was no significant difference in the value of magnesium in the samples under study as shown in Table 1. From the Table, it could be observed that although there was no significant difference in the values at $p \leq 0.05$, the freeze dried samples had the highest value of magnesium (0.097g/100g) closely followed by the cabinet dried sample which had a value of 0.090g/100g and the oven dried samples which had a value of 0.081g/100g. This implies that the drying method did not significantly affect the value of magnesium in the samples under study. This result is in line with the findings of Magara *et al.*, 2021 who reported a value of 0.00013g/100g for *Brachytrupesmembranaceus* and 0.09471g/100g for *Acheta domesticus*. The Potassium content of the freeze-dried samples had a significant higher

value (0.81g/100g) than the cabinet dried and the oven dried samples, which did not significantly differ from each other ($p \leq 0.05$), having values of values of 0.634g/100g and 0.552g/100g respectively as shown in Table 1. This implies that mild heat could slightly reduce the value of Potassium in the samples. Magara *et al.*, 2021 reported a similar value of 0.87726g/100g for *Brachytrypesspp* and 0.12662mg/100g for *Acheta domesticus*.

The Phosphorus content of the freeze-dried samples showed a high value of 0.092g/100g which did not significantly differ from the cabinet dried samples which had a value of 0.08g/100g but significantly differed from the laboratory oven dried samples ($p \leq 0.05$) which had a value of 0.063g/100g. This implies that laboratory oven drying had significant effect on the value of Phosphorus in the samples. This lower value of the oven dried samples may have resulted from the unequal distribution of heat during the oven drying, as the oven had no blower to evenly distribute the heat within the chamber and drive out moisture evenly from the samples matrix. Magara *et al.* (2021) reported a value of 0.1269g/100g for *BrachytrupesMembranaceus*, 0.0385g/100g for *Brachytrypesspp* and 0.8329g/100g for *Acheta domesticus*.

Table 1: Mineral profile of differently dried cricket samples

Mineral (g/100g)	CMDF	CMDOC	CMDOL
Calcium	0.023 $\pm$ 0.01 ^a	0.027 $\pm$ 0.00 ^a	0.009 $\pm$ 0.00 ^b
Magnesium	0.097 $\pm$ 0.01 ^a	0.09 $\pm$ 0.00 ^a	0.081 $\pm$ 0.00 ^a
Potassium	0.81 $\pm$ 0.07 ^a	0.63 $\pm$ 0.04 ^b	0.55 $\pm$ 0.01 ^b
Phosphorus	0.09 $\pm$ 0.00 ^a	0.08 $\pm$ 0.01 ^a	0.06 $\pm$ 0.00 ^b
Sodium	0.102 $\pm$ 0.01 ^a	0.097 $\pm$ 0.01 ^a	0.095 $\pm$ 0.00 ^a
Manganese	0.0025 $\pm$ 0.00 ^a	0.0009 $\pm$ 0.00 ^b	0.0008 $\pm$ 0.00 ^b
Iron	0.016 $\pm$ 0.00 ^a	0.015 $\pm$ 0.00 ^a	0.012 $\pm$ 0.01 ^a
Copper	0.004 $\pm$ 0.00 ^a	0.003 $\pm$ 0.00 ^a	0.013 $\pm$ 0.00 ^a
Zinc	0.016 $\pm$ 0.00 ^a	0.013 $\pm$ 0.00 ^b	0.015 $\pm$ 0.00 ^{ab}

Results are means for triplicate experiments $\pm$ standard deviation. Mean with different superscript along the row are significantly different ($p \leq 0.05$). CMDF-Freeze dried crickets; CMDOC-Cabinet dried crickets; CMDOL- Oven dried crickets

The Table further showed that there was no significant difference in the sodium content of the samples under study. The sodium content of the freeze-dried samples which had the highest value of 0.1025g/100g showed no statistical difference ($p \leq 0.05$) from the cabinet dried samples which had a value of 0.095g/100g and the oven dried samples which had a value of 0.0952g/100g. This implies that the drying method did not significantly affect the sodium content of African Giant Burrowing Crickets. Magara *et al.*, (2021) reported a similar value of 0.15022g/100g for *Brachytrupesspp* and 0.43506g/100g for *Acheta domesticus*. The result also showed that the Manganese content of the freeze-dried samples (0.0025g/100g) were significantly higher ($p \leq 0.05$) than the cabinet dried and the oven dried samples which had similar values of 0.0009g/100g and 0.0008g/100g respectively. This implies that mild hot air drying (30 - 45°C) had no significant effect on the Manganese value the samples while low temperature drying (-42°C) could significantly ($p \leq 0.05$) reduce Manganese losses in the samples. Magara *et al.*, 2021 reported a value of 0.00335g/100g for *Acheta domesticus*.

The Table further showed that there was no significant difference in the Iron content of the samples under study. The iron content of the freeze-dried samples which had the highest value of 0.016g/100g only slightly differed from the cabinet dried samples which had a value of 0.015g/100g and the oven dried samples which had a value of 0.012g/100g but was not statistically different from each other at $p \leq 0.05$. This implies that the drying method had no significant effect on the iron content of African Giant Burrowing Crickets. Magara *et al.*, 2021 reported a value of 0.68mg/100g for *BrachytrupesMembranaceus*, 0.03360g/100g for *Brachytrupesspp* and 0.008.75g/100g for *Acheta domesticus*. The oven dried samples had the highest value of copper (0.0128g/100g) but was not significantly different from the from the freeze-dried samples which had a value of 0.004g/100g and the cabinet dried samples which had a value of 0.003g/100g. This implies that sublimation drying and mild hot air (30 - 45°C) drying method had no effect on the copper content of African Giant Burrowing Crickets. Magara *et al.* (2021) reported a similar value of 0.00143g/100g for *Acheta domesticus*. The zinc content of the differently dried samples under study shows that the freeze-dried samples had the highest value of 0.016g/100g and was significantly higher ($p \leq 0.05$) than the cabinet dried samples which had a value of 0.013g/100g but was not significantly different from the oven dried samples which had a value of 0.015g/100g. Magara *et al.* (2021) reported a value of 0.02302g/100g for *Brachytrupesspp* and 0.02022g/100g for *Acheta domesticus*.

4.0 Conclusions

This study reveals the mineral profile of African giant burrowing cricket (tobacco cricket) dried using different drying methods. The study revealed that drying method generally affected the value of minerals in the samples under study. The freeze-dried samples generally contained higher quantity of minerals while the oven dried samples generally had the least quantity of minerals. The result also revealed that among the minerals analysed, Potassium is the most abundant in the samples, with freeze-dried samples having the highest potassium content,

while Manganese is the least abundant among all the minerals analysed. The study also showed that though freeze-dried samples significantly had higher value of Manganese than the hot air-dried samples, there was no significant difference in the Manganese content of the samples dried using hot air method. The values obtained in this study is generally similar to values reported in literatures for insects in the same family.

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PRODUCTION AND QUALITY EVALUATION OF BEEF BOUILLON CUBES FROM SEEDS AND LEAVES OF *Piper guineense* AND LEAVES OF *Ocimum basilicum* AND *Ocimum gratissimum*.

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Abstract

One of the dietary strategies for the mitigation of metabolic disease is the inclusion of plant foods in the diet. Diets rich in plant foods are sources of phytochemicals with healthful properties. The leaves and seeds of *Piper guineense*(uziza), and the leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum*(scent leaves) are culinary aromatic plant foods, nutritious, rich in phytochemicals and of high cultural values in Nigeria. The addition of the herbs and spices in bouillon cubes could increase consumer appeal. The present study produced two bouillon cube samples: one from the leaves and seeds of *Piper guineense* and another from the leaves of *Ocimum basilicum*(curry leaves) and *Ocimum gratissimum*. The phytochemical, proximate, heavy metals, micronutrients and acceptability of bouillon cubes samples were studied against a commercial sample: Knorr. The results showed that the *uziza* and scent leaves bouillon cubes had higher moisture, fiber, fat, vitamin A and E, potassium, magnesium, calcium, carotenoids and polyphenolic contents. The Knorr cube sample had higher protein, ash, carbohydrate, vitamin C, sodium and iodine values. The bouillon cubes had similar sensory values as the Knorr cubes. The leaves and seeds of *Piper guineense*, *Ocimum basilicum*(curry leaves) and *Ocimum gratissimum*(basil leaves)should be incorporated in the production of bouillon cubes.

Keywords: *Piper guineense*(uziza), *Ocimum basilicum*(curry leave), *Ocimum gratissimum*(curry leave),bouillon cube.

Introduction

Diets based on plant foods have been identified as an adjustable risk factor in the development and progression of metabolic diseases such as cardiovascular diseases and their co-morbidities. Plant foods promote health and mitigate diseases by the provision of micro-, macro- and phytonutrients in the diet. The leaves and seeds of *Piper guineense*, and leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* are aromatic plant foods known for their great culinary; insecticidal; macro-, micro- and phyto-nutrients and medicinal values (Ochei *et al.* 2017). *Piper guineense* is locally known in Nigeria as *Ata iyere* (Yoruba), *uziza* (Igbo), *Ebe-ahinhi akpoke/ Enie* (Edo), *Etinkene/ Adusa* (Efik) and *Masoro* (Hausa). *Ocimum gratissimum* is known as *Nchu-anwu* in Igbo, *Efinrin* in Yoruba, *Aramogbo* in Edo and *Daidoya* in Hausa.

Herbs have been used since ancient times for flavourings, aromatic compounds and medicines (Tapsel *et al.*, 2006). The terms ‘herb’ and ‘spice’ are often conversely used to describe culinary aromatic plants. However, ‘the leaf of a plant used in cooking may be referred to as a culinary herb and any other part of the plant, often dried as a spice’ (Nwankwo *et al.*, 2014). Herbs and spices may be regarded as functional foods because they contain bioactive antioxidative

phytochemicals that delays the progression of several degenerative diseases. Some identified phytochemicals in *Piper guineense* are alkaloids, flavonoids, glycosides, essential oils, tannins, saponins, peptides and phenolics. Bouillon cubes are used to enhance the umami taste of savory dishes. They are added to foods to improve the taste outcome of foods, thereby improving palatability. Commercial bouillon cubes are made from salt, sugar, flavour enhancers such as monosodium glutamate, herbs, spices, vegetables and food-grade colors, flavors and fragrances. They are processed by boiling and blending the ingredients with fat and oil materials and they are then pressed into cubes (Mejia *et al.* 2015).

Inclusion of *Piper guineense* seeds and leaves and leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) in commonly eaten foods like bouillon cubes, could be a population-based and intentional nutritional intervention in disease risk management.

Occasionally, quality parameters such as sensory, convenience and physicochemical parameters determine consumer preference of foods more than nutritional values. This study therefore aimed to determine the sensory and physicochemical values in addition to the nutritional, heavy metal and phytonutritional composition of bouillon cubes developed from leaves and seeds of *Piper guineense*, and leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves).

Materials and Methods

Procurement of materials

The leaves and seeds of *Piper guineense*, and leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves), fresh carrots, knorr bouillon cubes, olive oil, onions, red bell pepper, yellow bell pepper, garlic, Irish potatoes, cow bone, beef, turmeric, baker's yeast and salt were purchased at Eke-Awka Market in Awka, Anambra State, Nigeria. The equipment used for the preparation of samples and chemical analysis were gotten from the Department of Food Science and Technology, Chukwuemeka Odumegwu Ojukwu University, Anambra State. All the reagents used for the study were analytical grade. .

Preparation of yeast extract and Preparation of bouillon cubes

Baker's yeast (500g) was boiled in 2 liters of water for 4 hours and the water filtered to obtain yeast extract. The yeast extract was centrifuged at 4000rpm for 5 minutes and the supernatant used as the yeast extract

The production formulation for the two samples of bouillon cubes produced is shown in Table 1. The methods of Rodrigues *et al.*, (2016) were used. The beef and cow bones were thoroughly washed with clean salted water and the salt rinsed off by washing in clean water.. The leaves and seeds of *Piper guineense*, and leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) and other fresh vegetables were also washed with salted water and rinsed with clean water. The vegetables were chopped. The beef and cow bone were boiled for 6hours to extract the beef broth, after which the broth was filtered. The chopped onion, garlic, carrot and potato were stir-fried in olive oil at low heat for 4 minutes and added to the beef broth and boiled for 45 minutes. Salt, bay leaves, red bell pepper, yellow bell pepper, turmeric and yeast extract were added to the beef broth. The beef stock boiled with carrots, potato, onions, etc was prepared for each of the two varieties of the bouillon under study. In

one of the beef stock, the blended seeds and chopped leaves of *Piper guineense* were added, while the chopped leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) were added in another beef broth. and these were boiled additionally for ten minutes. After boiling, the bay leaves were removed and each of the boiled mixtures was blended together into a smooth paste. The paste was concentrated at low heat in a sauce pan for 30 minutes and shaped into cubes, placed on a baking tray, covered with moisture absorbent paper and then placed in an air drying oven. They were dried at 65°C for 4 hours. Afterwards, they were wrapped in aluminum foil and clean papers, placed and covered in glass bottles and kept in a refrigerator until analyzed.

Chemical analysis and Statistical analysis

The Proximate and micronutrients determinations of the samples were done according to the methods of AOAC (2006). Physicochemical, phytochemicals and heavy metal analysis were determined by the methods of Onwuka (2005). Sensory evaluation was carried out on the samples using Knorr bouillon cube as control to determine the level of acceptability. Ten-member panelists drawn out from students and staff of the Department of Food Science Chukwuemeka Odumegwu Ojukwu University, Anambra State carried out a sensory evaluation on the three samples. The parameters analysed were: appearance, aroma, taste, texture, mouth-feel, after taste and overall acceptability.

All determinations were done in duplicates using the Completely Randomized Design (CRD). The data obtained was analysed using one-way analysis of variance (ANOVA) in the Statistical Packaging for Social Sciences (SPSS) statistical software, version 21. Statistical differences of the mean samples were determined using the least significance difference (LSD) ($p < 0.05$).

Table 1: Ingredient formulation for the preparation of bouillon cubes from leaves and seeds of *Piper guineense* and leaves of *Ocimum basilicum* and *Ocimum gratissimum*

Ingredients	<i>Piper guineense</i> (PG) leaves and seeds bouillon cube	<i>Ocimum gratissimum</i> and <i>Ocimum basilicum</i> (OBOG) leaves bouillon cube
Scent leaves	-	7.5g
Basil leaves	-	7.5g
Uziza seeds	5g	-
Uziza leaves	10g	-
Beef broth	10g	10g
Yaest extract	10g	10g
carrots,	5g	5g
Bay leaves	5g	5g
Irish potatoes	5g	5g
Red bell pepper	2g	2g
Yellow bell pepper	2g	2g
Turmeric	4g	4g
Olive oil	5g	5g
Salt	22g	22g
Onion	4g	4g
Garlic	4g	4g

Results and Discussions

The data in Table 2 shows the nutritional, physicochemical, phytochemical and sensory qualities of two varieties of bouillon cubes prepared from the leaves and seeds of *Piper guineense* (West African Black Pepper/Ashanti black pepper), *Ocimum basilicum* and *Ocimum gratissimum*. The two study samples showed higher moisture content (31.88 and 24%) than the Knorr (3.94). Reduced moisture content helps to extend the shelf life of food products. Quality parameters such as taste, texture and appearance depend on moisture content of food. Reduced moisture content increases the concentration of nutrients per unit area of food sample. This might explain why the Knorr cube had significantly ($p < 0.05$) higher value of protein (9.66%) and ash (49.2) contents. Ash content of foods shows the inorganic residue or total quantity of mineral matter in the food. The range of crude fiber content in the samples was: 2.8-3.59% and there was no significant difference ($p < 0.05$) seen. Crude fiber estimates the quantity of cellulose and other non-sugar polysaccharides in foods. Crude fiber is important in maintaining colon health and protects against cancer and coronary heart disease (Yadilal *et al.*, 2017). Vegetables are not rich sources of oil, however, the bouillon samples made from *Piper guineense*, *Ocimum basilicum* and *Ocimum gratissimum* significantly ($p < 0.05$) increased the quantity of fats in the samples. This might be as a result of the olive oil used in stir-frying some of the vegetables. The proximate values for the Knorr cubes were similar to results obtained by Akpanyung (2005).

Vitamin A and E were higher in the bouillon samples made from the leaves and seeds of *Piper guineense*, *Ocimum basilicum* and *Ocimum gratissimum*, while vitamin C was higher in the Knorr cube sample. The sample containing the leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) showed the highest vitamin A (5.78 mg/100g) and E (14.31mg/100g) contents with significant differences ($p < 0.05$). Potassium, magnesium and calcium were higher in the OBOG and PG samples. On the other hand, sodium and iodine were significantly higher ($p < 0.05$) in the Knorr cube sample. Bouillon cubes produced in Nigeria are fortified with iodine which explains the high level of iodine in the knorr sample. Sodium is responsible for the regulation of acid-base balance and muscle contraction. However, a diet rich in sodium is a risk factor for the development of hypertension. Carotenoids and polyphenols were also significantly ($p < 0.05$) higher in the OBOG and PG bouillon cubes. Carotenoids and polyphenols are bioactive compounds that reduce inflammation and progression of several metabolic diseases such as cancer, hypertension and diabetes. The leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) increased vitamin A and E, potassium, calcium, polyphenolic and carotenoid contents more than the combination of the leaves and seeds of *Piper guineense* (uziza). Nwankwo *et al.*, (2014) showed that *Ocimum gratissimum* have better nutritional values than the leaves of *Piper guineense*. Total soluble solids occurred highest (8.87%) in the Knorr samples. Total soluble solids are as a result of dissolvable solids. Titrable acidity and pH were higher 5.12% and 4.56 in the knorr samples. Viscosity was highest (1.95 and 2.11 m.pas) in the OBOG and PG samples compared to the knorr cubes.

Lead and cadmium were higher in the knorr sample than the PG and OBOG samples. However, the levels in all the samples were below the recommended minimum limit (USFDA, 2022). From the sensory analysis, the aroma, color and aftertaste of the PG and OBOG were significantly preferred, while the taste and texture of the knorr sample was significantly

preferred. However, there was no significant difference in the mean sensory values of the three samples.

Table 2: Quality evaluation of bouillon cubes prepared from the leaves and seeds of *Piper guineense* (PG)(West African Black Pepper/Ashanti black pepper), *Ocimum basilicum* and *Ocimum gratissimum* (OBOG).

Parameters	Bouillon cube from <i>Piper guineense</i> (PG)	Bouillon cube from <i>Ocimum basilicum</i> and <i>Ocimum gratissimum</i> (OBOG)	Knorr bouillon cube
Proximate Composition			
Moisture%	31.88 ^c ± 2.80	24.00 ^b ± 2.80	3.94 ^a ± 0.20
Protein%	6.10 ^a ± 0.740	5.40 ^a ± 0.03	9.66 ^b ± 0.16
Fat%	3.04 ^b ± 0.05	3.33 ^b ± 0.22	1.40 ^a ± 0.14
Ash%	30.40 ^a ± 0.02	30.60 ^a ± 1.83	49.20 ^b ± 0.05
Fiber%	2.80 ^a ± 0.15	3.59 ^a ± 0.21	2.58 ^a ± 3.42
Carbohydrate%	25.70 ^a ± 3.5	31.60 ^{ab} ± 3.25	35.50 ^b ± 0.00
Micronutrients			
Vitamin A (mg/100g)	2.96 ^b ± 0.04	5.78 ^c ± 0.02	0.44 ^a ± 0.03
Vitamin C (mg/100g)	11.43 ^a ± 0.07	11.77 ^a ± 0.25	17.63 ^b ± 0.07
Vitamin E (mg/100g)	4.84 ^a ± 1.24	14.31 ^b ± 0.38	3.47 ^a ± 0.80
Potassium (mg/100g)	33.94 ^b ± 0.44	34.25 ^b ± 0.38	26.24 ^a ± 0.27
Sodium (mg/100g)	98.34 ^a ± 2.09	100.03 ^a ± 0.80	105.19 ^b ± 1.34
Iron (mg/100g)	0.73 ^a ± 0.01	0.97 ^a ± 0.40	3.40 ^b ± 0.08
Magnesium (mg/100g)	27.80 ^c ± 0.04	23.33 ^b ± 0.04	15.13 ^a ± 0.18
Calcium (mg/100g)	40.00 ^b ± 0.02	46.60 ^c ± 0.07	13.30 ^a ± 0.05
Iodine (mg/100g)	0.00 ^a ± 0.01	0.00 ^a ± 0.00	2.95 ^b ± 0.21
Phytochemicals			
Carotenoids (mg/100g)	36.44 ^b ± 0.26	49.33 ^c ± 0.68	4.08 ^a ± 0.48
Polyphenols(mg/100g)	12.06 ^b ± 0.30	12.23 ^b ± 0.07	7.60 ^a ± 0.060
Physicochemicals			
Total soluble solids %	3.69 ^a ± 1.14	4.17 ^a ± 0.70	8.87 ^b ± 0.04
Titrateable acidity%	2.88 ^a ± 0.30	3.17 ^a ± 0.07	5.12 ^b ± 0.30
Ph	4.51 ^a ± 0.01	4.53 ^a ± 0.10	4.56 ^a ± 0.04
Viscosity (m.pas)	1.95 ^b ± 0.11	2.11 ^b ± 0.04	1.56 ^a ± 0.02
Heavy metals			
Lead(µg/100g)	0.10 ^a ± 0.01	1.31 ^b ± 0.11	1.65 ^c ± 0.07
Cadmium (µg/100g)	1.00 ^b ± 0.12	0.05 ^a ± 0.07	1.84 ^c ± 0.07
Sensory Evaluation			
Appearance	5.50 ^a ± 1.59	6.60 ^a ± 1.07	5.50 ^a ± 1.08
Aroma	6.60 ^a ± 1.30	6.40 ^a ± 1.40	5.60 ^a ± 1.20
Taste	5.50 ^a ± 1.20	5.10 ^a ± 0.60	6.70 ^b ± 1.40
Texture	5.20 ^a ± 0.42	5.20 ^a ± 0.97	5.50 ^a ± 0.65
Mouthfeel	5.40 ^a ± 0.97	5.00 ^a ± 0.08	5.30 ^a ± 0.95
After taste	6.00 ^b ± 0.94	5.70 ^b ± 0.82	5.50 ^{ab} ± 0.71
Mean score of sensory values	5.80 ^a ± 0.60	5.70 ^a ± 0.40	5.70 ^a ± 0.70

Data values are expressed as means of triplicates $\pm$ standard deviation. Values in the same row with the same superscript are not significantly different ($p < 0.05$). Values of sensory scores were: 9= liked very much; 8= liked much; 7=liked moderately; 6=liked slightly; 5=Neither liked nor disliked; 4=disliked slightly; 3=disliked moderately; 2= disliked much, and 1=disliked very much.

Conclusion

The findings of this study showed that the sensory value, phytochemical, micro and macro-nutrients of bouillon cubes can be significantly ($p < 0.05$) increased by the inclusion of the leaves and seeds of *Piper guineense* (uziza), *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) in the production of bouillon cubes. The leaves and seeds of *Piper guineense* (uziza), *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) significantly ($p < 0.05$) increased the fat, fiber, vitamin A and E, potassium, magnesium, calcium, polyphenolic and carotenoid values, as well as appearance, aroma, after-taste and mouthfeel of bouillon cubes. Phytochemicals are important in the control of metabolic diseases. The leaves of *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves) increased vitamin A and E, potassium, calcium, polyphenolic and carotenoid contents more than the leaves of *Piper guineense* (uziza). While the leaves of *Piper guineense* (uziza) increased magnesium, aroma and mouthfeel of the samples. The high iodine content of the knorr sample is a proof that bouillon cubes in Nigeria are fortified with iodine. This study therefore showed that acceptable bouillon cubes with increased nutritional content can be produced from the leaves and seeds of *Piper guineense* (uziza), *Ocimum basilicum* (curry leaves) and *Ocimum gratissimum* (scent leaves). This could increase the utilization of these herbs and spices as nutritious industrial flavoring additives in the production of bouillon cubes and other foods condiments. Consequently, there would be increased revenue to the farmers concerned.

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ANTIMICROBIAL ACTIVITY AND PRESERVATIVE POTENTIALS OF BACTERIOCIN EXTRACTS ON BEEF.

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Abstract

Preservation and inhibition of microbial growth in food using bio-friendly substances has increasingly gained global attention in the food industry. In this study, the antimicrobial activity of bacteriocin against selected pathogenic bacteria and its bio preservative efficacy on homogenized beef was evaluated. The antimicrobial activity of the isolates was determined by growth inhibition test against *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Clostridium botulinum*. The bio preservative activity of the isolates on beef was also determined using plate count method. The result obtained was subjected to descriptive statistical analysis. The result revealed higher zone of inhibition on gram positive (+ve) bacteria isolates when compared to the gram negative (-ve) bacteria. The antimicrobial activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa* when compared to *Escherichia coli* and *Salmonella typhi*. The results also revealed that in the overall effectiveness of the bacteriocin to inhibit the pathogenic selected isolates, the most effective bacteriocin that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. The effect of bacteriocin concentration on bacteria count of homogenized beef sample revealed that the control sample had higher microbial count when compared with the other samples. The mixture of the bacteriocin extracts with homogenized meat sample revealed lowered microbial count corresponding to increase in concentration of the bacteriocins. It is therefore concluded that crude bacteriocin produced from Lactic Acid Bacteria had significant inhibition against the tested organisms. It is also concluded that effectively reduced the bacterial count in beef.

Keywords: Bacteriocin, Antibacterial, Antimicrobial activity.

1.0 INTRODUCTION

Lactic acid bacteria (LAB) are able to produce antimicrobial substances such as bacteriocins which have great potential to be used in therapeutics and as food bio-preservatives (Arokiyamy, 2012). The term bacteriocin is mostly used to describe the small, heat-stable cationic peptides synthesized by Gram positive bacteria, namely lactic acid bacteria (LAB), which display a wider spectrum of inhibition (Vijet *et al.*, 2011). A number of chemical compounds have been used to inhibit pathogens and spoilage organisms associated with foods so as to preserve the foods for long time, however, bacteriocin has caught the attention of food scientists as a natural food preservative with potential antimicrobial activity that could lead to improvement in shelf life of food and inhibition of pathogenic bacteria. The increase in

antibiotics resistance has also been challenging and thus the need to constantly search for active alternative sources to forestall future challenges (Holmes *et al.*, 2016). This has encouraged scientists to reassess alternative therapeutic options. This study aims to explore the antibacterial activity of crude bacteriocin from *Lactobacillus jensenii* JV-V16, *Lactobacillus crispatus* STI, *Lactobacillus sakei* and *Lactobacillus salivarius* against selected pathogenic bacteria.

2.0 MATERIALS AND METHODS

2.1 Screening of Bacteriocin for Antimicrobial Activity

Antimicrobial activity of bacteriocin extracts of Lactic Acid Bacteria (LAB) isolates from fresh cow milk against pathogenic microorganisms was determined by well diffusion method under aerobic conditions. Agar plate was inoculated with 500 µl of each indicator microorganisms namely; *Lactobacillus jensenii* JV-V16, *Lactobacillus crispatus* STI, *Lactobacillus sakei* and *Lactobacillus salivarius* after growing them in nutrient broth and diluting appropriately. The inhibitory activity against the pathogenic microorganism was tested on plate containing Mueller Hilton Agar plate and 150 µl of cell free supernatant (Crude bacteriocin) of isolated strain was added into each well. Plates were incubated at 37°C for 24 hour. The antimicrobial activity was determined by measuring the diameter of the inhibition zones around the wells as described by Bromberg *et al.* (2004).

2.2 Biopreservative Efficiency of Bacteriocin on Beef

The food product (beef) was aseptically obtained from an open market, and immediately conveyed to the laboratory where it was homogenized and serially diluted at 10^{-6} . A portion (control) of homogenized beef was examined for total plate count (TPC) at an incubation temperature of 37°C for 24 hrs. Purified bacteriocin was added to the other portion of the homogenized beef sample at different concentrations (0.5 mg/ml, 1 mg/ml, 2 mg/ml, and 4 mg/ml). The colony count of the bacteriocin mixed samples and the control sample were recorded. The experiment was carried out in triplicates and the result obtained were subjected to statistical analysis and presented in charts to provide a clear representation of the outcome.

3.0 RESULTS AND DISCUSSION

3.1 Antimicrobial Activity of Crude Bacteriocin produced from Lactic Acid Bacterial on Some Bacterial Isolates

The result of the Antimicrobial activity of crude Bacteriocin produced from Lactic Acid Bacterial on some bacterial isolates are presented in figure 1. Higher zone of inhibition was observed in gram positive (+ve) bacteria isolates when compared with the gram negative (-ve) organisms. The result also showed that *Lactobacillus jensenii* JV-V16 was more effective on *Staphylococcus aureus* and *Clostridium botulinum* when compared to others. Also, *Listera monocytogenes* exhibited higher zone of inhibition on addition of bacteriocin produced from *Lactobacillus crispatus* when compared to *Staphylococcus aureus* and *Clostridium botulinum*. The antimicrobial activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa*, when compared to *Escherichia coli* and *Salmonella typhi*. This showed zone of inhibition on addition of bacteriocin produced from *Lactobacillus jensenii* JV-V16.

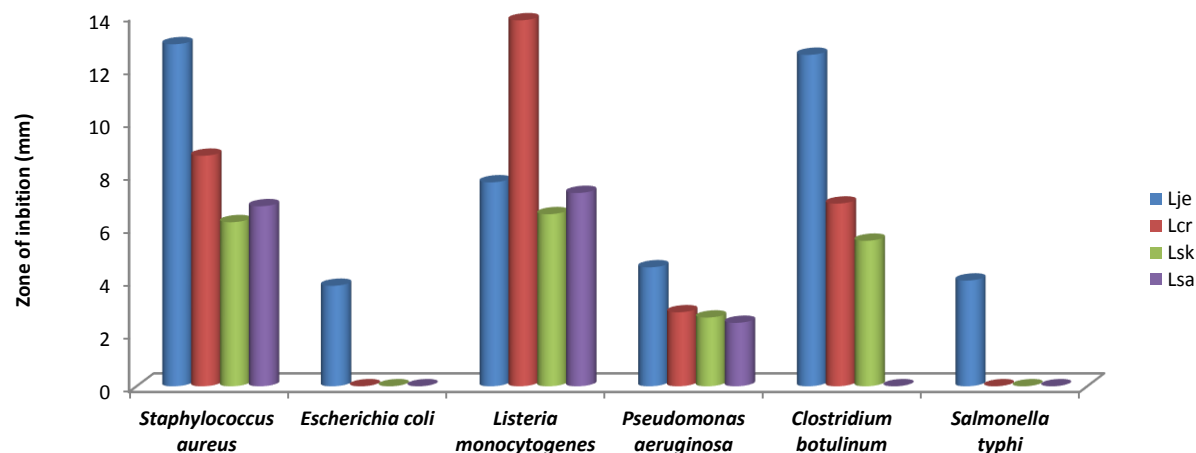


Figure 1: Antimicrobial Activity of Crude Bacteriocin produced from Lactic Acid Bacteria on Some Bacterial isolates

LJe= *Lactobacillus jensenii* V-V16, Lcr= *Lactobacillus crispatus* ST1, Lsk= *Lactobacillus sakei*, Lsa= *Lactobacillus salivarius*

The bacteriocin from the isolated *Lactobacilli* appears to have significant inhibition against the tested organisms except for *E. coli* and *S. typhi* which resisted the bacteriocin from *L. crispatus*, *L. sakei* and *L. salivarius*. In the order of the overall effectiveness of the bacteriocin to inhibit the pathogenic selected isolates, the most effective bacteriocin that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. Several studies reported varying output in the use of *L. salivarius* in various treatment study of human ailments and diseases either as probiotics or inhibitory ability via bacteriocin (Iwamoto *et al.*, 2010), however, *L. salivarius* was least active in this study. In contrary to this result, the antibacterial and anti-inflammatory capability of bacteriocin against the causative organism of acne i.e. *Propionibacterium acnes* was impressive due to its ability to inhibit the release of chemokine Interleukin-8 (IL-8) in comparison with previous topical and oral antibiotics (Deidda *et al.*, 2018). Furthermore, in a research to fight food borne illness caused by *L. monocytogenes*, Corret *al.* (2007) reported that the bacteriocin produced labelled Abp118 exhibited a direct antagonism against the pathogen in the infected mice. The outcome of this study presented in figure 1 also supports the inhibitory capability of bacteriocin produced by *L. salivarius* against *L. monocytogenes*. Compounds from *Lactobacillus jensenii* and *crispatus* have been reported to possess antimicrobial properties. This is also corroborates to the result of this study where the bacteriocin inhibitory effect was evident. Wang *et al.* (2017) reported similar results while working on strategies to minimize adverse effect of salinity on aerobic granular sludge. Additionally, Mobarez *et al.* (2008) reported the active inhibition of bacteriocin-like compounds from *Lactobacillus* spp against *P. aeruginosa* and *S. aureus*.

3.2 Effect of bacteriocin concentration on bacterial count of homogenized Beef

The effect of bacteriocin concentration on bacteria counts of homogenized beef samples are shown in figure 2. The result showed that the control sample had higher microbial count (5×10^6 cfu/g) when compared with the other samples. The bacterial count was observed to decrease with increase in bacteriocin concentration.

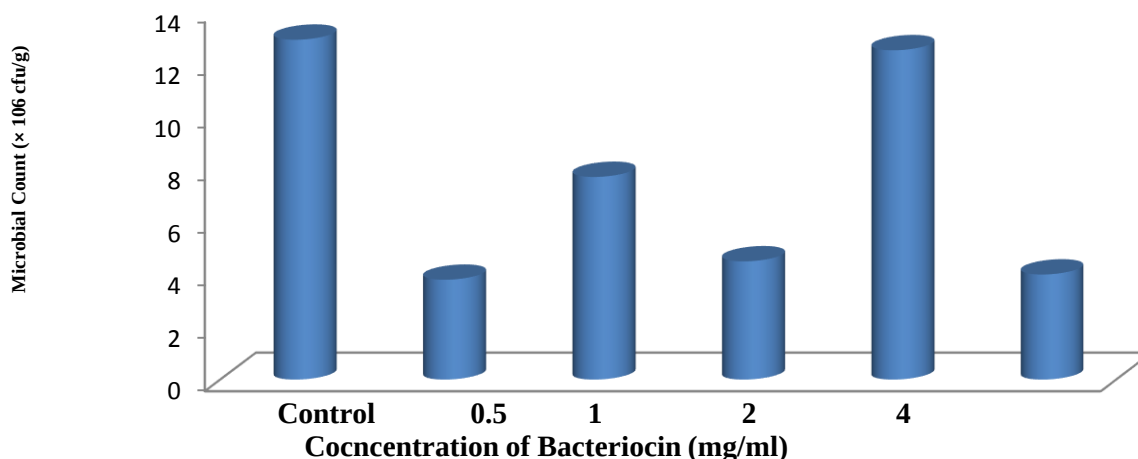


Figure 2: Effect of bacteriocin concentration on bacterial count of homogenized Meat Sample

Bio-preservation is an important approach to maintain the microbiological quality and safety of meat and meat products. This technique is used to extend food shelf-life through the application of a protective microbiota such as the use of lactic acid bacteria (LAB) with their antibacterial properties and the production of bacteriocins. Bacteriocins are small peptides or bioactive proteins, ribosomally synthesized by Gram-positive and Gram-negative bacteria and extracellularly released. The antimicrobial property exhibited by bacteriocin on the homogenized meat sample justifies the biotechnological potential of bacteriocins (Behrens *et al.*, 2017). In contrary to the result obtained in this study, Cho *et al.* (2010) reported a failure of bacteriocin of *L. plantarium* BFE5092 in turkey meat, while in the meat industries, pediocin PA-1 or this bacteriocin-producing culture is known to reduce the growth of spoilage microorganisms during storage.

4.0 CONCLUSION

The antimicrobial activity of crude Bacteriocin produced from Lactic Acid Bacterial on some bacterial isolates and the effect of bacteriocin concentration on bacteria count of homogenized beef sample are revealed in this study. The study revealed a higher zone of inhibition in gram positive (+ve) bacteria isolates when compared with the gram negative (-ve) organisms. The antimicrobial activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa* when compared to *Escherichia coli* and *Salmonella typhi*. The study also revealed that in the order of the overall effectiveness of the bacteriocin to inhibit the pathogenic selected isolates, the most effective bacteriocin that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. The effect of bacteriocin concentration on bacteria count of homogenized

beef samples revealed that the control sample had higher microbial count when compared with the other samples. The study revealed that the bacteria count decreased with increase in bacteriocin concentration. It is therefore concluded that crude Bacteriocin produced from Lactic Acid Bacteria had significant inhibition against the tested organisms. It is also concluded that it effectively reduced the bacteria count in beef.

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**THE TAXONOMY OF SOME EDIBLE INSECTS AND THE
MICRONUTRIENT COMPOSITION OF TWO EDIBLE INSECTS' LARVAE
AND A WHITE ANT**

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ABSTRACT

The study involved the taxonomy classification of *Rhynchorusspp*, *Macrotermesspp*, *Imbrasiaspp*, *Achetasspp*, and *Zonoceruspp* among others. Also the micronutrient assays showed significant contents of Calcium, Iron, Magnesium, Zinc and Sodium in the insects from *Rhynchorusspp* and *Macrotermesspp* group of insects studied. Consumption of these insects is recommended.

Keywords: *Rhynchorusspp*, *Macrotermesspp*, *Achetasspp*, *Zonoceruspp*, *Micronutrients*.

INTRODUCTION

Africa remains the region with the highest prevalence of undernourishment and malnutrition, and so continues to grapple with food and nutrition insecurity. Malnutrition implies an imbalance (too much or too little intake of essential nutrients), resulting in poor nutrition and health. Under-nutrition or under nourishment occurs when there is dietary deficiency for one or more nutrients and this can lead to deficiency diseases. Protein-Energy malnutrition is reportedly prevalent in the rural areas of Nigeria, due to high cost of conventional protein food, (Ojinnaka *et al* 2013). In order to maintain health, the essential nutrients namely, macro and micronutrients must be obtained from food since the body cannot synthesize them, (Murano 2003). Micronutrients include both vitamins and minerals. The minerals have chief or principal roles in the body, and each mineral can be sourced from both plant and animal food products, including insects. About 70% -80% of all named animal groups on earth are insects (Premalatha *et al* 2011). Insects are invertebrates that belong to the phylum, arthropoda. Arthropods are characterized with chitinous exoskeleton, a three parts body (head, thorax and abdomen) and three pairs of jointed legs, a compound eye and two antennae. They are found in all sorts of habitats and environments. A small number of arthropods species e.g., crustaceans occur in ocean where they feed and maintain habitation. Insects are the only invertebrates that can fly. Although they are generally regarded as pests to humans, they represent the cheapest source of animal protein.

According to Van Huis *et al.*, (2013), insects have served as traditional foods among indigenous people especially in Africa, Asia and Latin America. It is not surprising therefore that insects have long been in deliberate use as human food and animal feed globally including in West Africa. However, consumption of insects is less widely practiced in west Africa when compared with other regions in sub-Saharan Africa (Kenis and Hein, 2014),

probably due to varied degrees of cultural bias and the fact that as small as they are, insects are harvested from the wild. Considering the popularity of edible insects, scores of species have been and are prominent items of commerce in towns and village markets of Africa, tropical and semi tropical regions of the world, (De- Foliart, 2002). For example, roasted ready-to-eat winged termites are sold in large quantities in many markets in the eastern parts of Nigeria especially during rainy season, and many families make a fairly good living from such sales. Much of *Rhylochoprousspp* larvae harvested from the creeks of River Niger are processed and sold to consumers along Onitsha Owerri road and bus commuters also patronize their hawkers. The sales of fried palm weevils are common sights in Warri area of Delta State. All of the above are more than concrete evidence that insects are prominent edibles as traditional foods. Edible insects are eaten at different stages of life e.g., at the immature stage (eggs, larvae, pupae and nymphs) and in some cases also at adults stage, (Anankware *et al* (2015). The most commonly consumed insects are beetles: 31 % (Van Huis *et al* 2013). Consumption of caterpillars (larvae) is estimated at 18%, 14% for Bees, wasp, ants and grasshoppers. Locust and crickets are consumed at about 13%, leaf hoppers, 3% and, others, (Van Huis *et al*2013). The larvae forms or adult forms of edible insects can be consumed with little or no processing in different parts of Nigeria. *Rhynochorusspp* larvae (of Coleoptera order), and termites of Isoptera (of Lepidoptera order) respectively (Nzelu (2010) are examples. Van Huis (2003) reported the percentage of edible insects per “order” Out of the 470 insect species from their survey, 256 edible insects species in Central Africa, were found 164 species were found in Southern Africa while 100 and 91 species were found in Eastern Africa and Western Africa respectively. Only 8 species were found in Northern Africa. The major groups of edible insects consumed globally and their taxonomical orders include.

Edible insects are beneficial to humans and are part of the traditional foods in Nigeria. Crops rely on insects for pollination and consequently insects are important for food production and for health issues. Honey for example produced by bees heals wounds and soothes sore throats and coughs. Insects play essential role in minimizing food insecurity. According to Kelemu *et al* (2015) insects also support nutrition, supplying up to 40- 70% protein, (Adegbola *et al* 2013); variable fat of up to 35%, 1 - 29% carbohydrate (Kelemu *et al* 2015). Despite the large variation in the nutritional composition from insects, they provide satisfactory energy and protein in addition to meeting amino acid requirements for humans. They are also rich in several minerals and vitamins i.e., micronutrients that play important roles in the nutritional value of food. This study was aimed at identifying some edible insects in South Eastern States of Nigeria and determining the mineral composition of *Rhynochphorous* species and white ant (edible mandibulate soldier ant).

MATERIALS AND METHODS

1. *Procurement and Identification of Insects*

Children of St. Luke’s Church Primary School, Ibolo, Oraifite, Ekwusigo Local Govt. Area, Anambra State, were mobilized to harvest grasshoppers from their school fields. Wine tappers were mobilized to harvest beetles larvae, and caterpillars from the swamps and fruit trees respectively. The white ant was harvested from a termite hill in Umunze, Orumba South Local Govt. Area, Anambra State.

2. *Analysis of samples*

Two types of *Rhynchophorus* spp larvae coded LG and LS respectively and, the white ant coded SA were later analysed for their mineral content. The coded samples were prepared as follows:

The LG (with 3 pairs of jointed legs), the LS (without the jointed legs), and the mandibulate soldier ant SA, having been harvested were placed in three different stainless steel, basins, and submerged fully each in 2 liters of boiled water. With stainless 2-pin frying spoons, the insects were turned from side to side within 5mins of stay within the boiled water, to ensure removal of the adhering sand and dirt. The boiling water-washing was repeated thrice for each edible insect after which the washed insects were air-dried using fans. About 500g of each of the LG, LS, and SA samples was separately weighed out and milled using electric blender. Atomic Absorption Spectrophotometer (AAS) method of Pomeranz and Meloan (1971). The insects were classified into various taxonomical groups. The insects group were confirmed by Mr. Onyebuchi, a taxonomist in Science Laboratory Department; Federal Polytechnic Oko, Anambra State, Nigeria.

3. *Statistical analysis*

Data from the determinations were collected in triplicates and, means $\pm$ standard deviations (SD) were computed. The means of data obtained were analyzed by one way analysis of variance (ANOVA) using the SPSS version 24 statistical procedure and significance was accepted at $P < 0.05$ level of probability. Differences between means were determined using Duncan's Multiple Range Test. Significance was accepted at 5% probability level.

RESULTS AND DISCUSSION

The common and scientific names of the edible insects collected were recorded on Table 1. Among the insects collected were two (2) species of Isoptera (*Macrotermes* spp) and three species of insects of the order Orthoptera namely house cricket, locust and some horned grasshoppers. In the order of Coleoptera, larvae and beetles of *Rhynchophorus* spp were also collected, while *Imbrasiabelina* of the Lepidoptera order was also harvested.

TABLE 1: SOME EDIBLE INSECTS SPECIES IN SOUTH EASTERN NIGERIA

CLASSIFICATION OF EDIBLE INSECTS IN THEIR CLASSES

Order	Family	Genus	Specie Scientific name	English: Common name	Example of local names Hausa, Igbo & Yoruba			Consumption stage
					H	I	Y	
Coleoptera	<i>Curculionidae</i>	<i>Rhynochphorus</i>	<i>Rhynochphorus</i> spp	Palm Larva	NK	akpa	"ipe"	Larva
	<i>Scarabaeidae</i>	<i>Rhynochphorus</i>	<i>Raphia palm larva</i>	<i>Raphia palm larva</i>	NK	akpa	"ipe"	and adult
	<i>Scarabaeidae</i>	<i>Rhynochphorus</i>	<i>Rhynochphorus</i> spp	Compost larva	NK	akpa	ogongo	Larvae
Orthoptera	<i>Gryllidae</i>	<i>Acheta</i>	<i>Achetadomesticus</i>	House cricket	NK	"abuzu"	"ire"	Adult
	<i>Acrididae</i>	<i>Gastrimargus</i>	<i>G. africanus</i>	Locusts	NK	igurube	ukpana	Adult
	<i>Pyrgomorphidae</i>	<i>Zonocerus</i>	<i>Zonocerus variagatus</i>	Grasshoppers	NK	Tata	NK	Adult
Lepidoptera (Butterflies & Moths)	<i>Saturnidae</i>	<i>Gomimbrasia</i>	<i>Imbrasiabelina</i>	Mopane worm or caterpillar	NK	egu/wiwi	ekuku	Larva
	<i>sapotaceae</i>	<i>Cirina</i>	<i>Cirinaforda</i>	<i>pallidempera</i> moth	NK	ekuku	manimani	larva
Isoptera	<i>Termitinae</i>	<i>Macrotermes</i>	<i>Macrotermes nigeriansis</i>	Winged Termites	NK	akumkpu	NK	Adult
		<i>bellicosus</i>		Soldier ants	NK	mkpujato	NK	Unwinged adult

Micronutrient compositions of the insects studied
mg/100g

Sample	Ca	Mg	Fe	Zn	Na
Coleoptera LG	5.66 ^a	10.01 ^b	2.17 ^c	0.01 ^c	17.00 ^a
Coleoptera LS	0.79 ^c	7.42 ^b	0.01 ^c	0.68 ^b	3.04 ^c
Isoptera SA	4.42 ^b	2.01 ^a	8.60 ^a	2.01 ^c	22.44 ^a

Values are means SD ($n=3$). Values with same superscript in the same column are not significantly different.

Key: NK = Not known at the time of writing, LG = Legged, LS = Legless, SA = Soldier Ant

Table 1, revealed both the classification of some specific edible insects of the orders Coleptera, Isoptera/Lepidoptera and Orthoptera respectively and, the micronutrient properties of LS, LG and SA sample. From these tables the morphology of the insects (larvae and beetles) could be seen. The larvae of *Rhynochphorus*spp coded LG and LS and, the soldier ant coded SA of Isoptera order had their micronutrients' results recorded on Table 1. The micronutrients determined from LS, LG and SA samples included Calcium (Ca^{++}), Iron (Fe^{++}), Magnesium (Mg^{++}), Zinc (Zn^{++}) and Sodium (Na^{+}) in mg/100g unit.

Their calcium (Ca) content ranged between 0.79mg/100g and 5.66mg/100g with LG having the higher quantity while the LS sample had the least. The chief role of Ca^{++} is for strong bones and teeth. Ca^{++} is also involved in muscle contraction and relaxation. Their magnesium (Mg^{++}) contents were 10.04mg/100g, 7.42mg/100g and 2.01mg/100g for LG, LS and SA samples respectively. According to Murano, (2003), Magnesium is involved in bone

mineralization, protein synthesis, enzyme action, normal muscular contraction and nerve transmission. Iron (Fe^{++}) content in the samples were 2.17mg/100g for LG, 0.01mg/100g for LS and 8.60mg/100g for SA. SA sample had the highest concentration of Fe^{++} . Edible insects have been credited as rich sources of iron, (Defoliart, 2002) and their inclusion in the daily diet could improve their iron sources and help prevent anemia in the developing countries. Fe^{++} helps in haemoglobin formation, is part of myoglobin and helps in energy utilization. Also, Fe^{++} deficiency can constitute a problem in the diet of pregnant women in the developing world, (Defoliart, 2002).

The results obtained for zinc (Zn^{++}) were 0.01mg/100g for SA, 0.068mg/100g for LG and 2.01mg/100g for LS. Zinc deficiency in diets especially for child and maternal health can lead to growth retardation, delay in sexual and bone maturation among others. For sodium (Na^+), LG contained 17mg/100g; LS contained 3.04mg/100g while SA contained 22.44mg/100g. Sodium helps to maintain normal fluid and acid-base balance and nerve impulse transmission (Murano, 2003). Quantitatively, the copper contents of Cu were 0.03mg/100g in LG, 0.22mg/100g and 0.87mg/100g. Though of low quantities in the three insects copper helps to make haemoglobin as well as being part of several enzymes in the body, Cu deficiency results in anemia among others, (Fox and Cameron 1989). Cobalt which forms part of Vitamin B₁₂ and is involved in nerve function and blood formation was obtained at 3.00mg/100g, 3.54mg/100g and 0.01mg/100g for samples LG, LS and SA respectively. Generally these micronutrients have animal foods as their rich sources so it is not a wonder that they are richly present in edible insects. They can however only be available to those who will ignore customs, prohibitions and bias and consume the processed edible insects.

TABLE 2: CLASSIFICATION OF SOME EDIBLE INSECTS OF THE ORDER

Order				
1 Coleoptero	Raphia palm Legless (Larvae and adult) 	Raphia palm Legged (Larvae and adult) 	Pam tree Larvae and adult 	Fruit tree Beetle 
2 Orthoptera	Green grasshoppers	Locusts 	Variegated grasshopper 	Edible house cricket 
3 Isoptero	Termite Early morning flight 	Termite Early evening flight 	Soldier ant	
4 Lepidptera	Caterpillar 			

CONCLUSION

Many edible insects often regarded as pests are available in Anambra State of Nigeria as in other places. Some minerals i.e., micronutrients can be sourced from these insects. Differences in the types and quantities of the minerals could be due to variations in the dietary habits of the insects. It could also be due to differences in the ecosystems or due to age of the insects. The results confirm that insects are good and cheap sources of micronutrients. The implication is that consumption of edible insects should be encouraged.

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PROTEIN ENRICHMENT OF FETTUCCHINE PASTA WITH LENTILS AND LEAN BEEF

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ABSTRACT

Pasta products are consumed all over the world in various forms. Although it is a staple food, it lacks some nutritional constituents, particularly essential amino acids. Wheat flour was substituted at 5% and 10% w/w with beef and lentils as protein sources and proximate composition and amino acids, were investigated. Addition of beef and lentils flour significantly ($p \leq 0.05$) increased the protein, fiber and essential amino acids in the fettuccine. This study showed that addition of beef into fettuccine improved the nutritional composition of pasta with the 10% beef flour fettuccine suggested for consumption. Though lesser in nutritional constituents, the 10% lentil flour fettuccine could equally be applicable for vegetarians.

Keywords: Amino acids, Nutrients, Vegetarian; Protein supplementation.

INTRODUCTION

Pasta is a staple food that originated from Italy and gained widespread popularity due to its convenience. Its increasing consumption is attributed to its palatability and relatively longer shelf life than other bakery products. The common forms of this pasta include lasagna, spaghetti, macaroni, ravioli and fettuccine. They are majorly categorized into two groups namely, dried pasta (*secca*) and fresh pasta (*fresca*). Most of dried pasta is commercially manufactured through extrusion operation, whereas fresh pasta is artistically manufactured by hand, occasionally with uncomplicated equipment. Fettuccine is a fresh pasta produced and widely accessible in the markets. Despite the popularity of pasta, it is generally deficient in some nutrients, particularly essential amino acids. Subsequent addition of an adequate protein source to improve its quality is indeed desirable and represents an excellent food vehicle for the delivery of essential nutrients to its teeming consumers. This assertion has been further substantiated by the World Health Organization (WHO) and Food and Drug Administration (FDA) that consider pasta as an effective conduit for incorporation of nutrition supplements (Chilloet *et al.*, 2008). According to Kadam and Prabhasankar (2012), addition of ingredients containing protein in pasta is also necessary to cater for conscious consumers that prefer having a product rich in protein and other beneficial components.

Beef contains high biological value protein and an important source of other micronutrients. Research has shown that consumption of meat is advisable because it serve as a source of protein, vitamins and iron (Biesalski, 2005). On the other hand, are vegans, which are known to abstain from consuming meat due to economic, environmental and religious concerns.

Irrespective of this, there is the constant need to meet the daily intake of protein which are important for body growth, repair of tissues and production of enzymes, hormones and other body chemicals, necessitating vegans to turn to plant sources for their protein's requirements. Lentil (*Lens culinaris* Medikus) is a food legume with protein contents of up to 30%, which positions them as an adequate meat substitute and also known to provide significant amounts of essential nutrients for healthy living (Siva *et al.*, 2017). This study therefore, investigated the protein, amino acid profile, selected physical characteristics and acceptability of a fettuccine pasta enhanced with plant (lentil) and animal (lean beef) protein.

MATERIALS AND METHODS

Materials

Wheat (*Triticum aestivum*) flour, lentils (*Lens culinaris* Medikus) and dried lean beef were purchased from a local market in Johannesburg, South Africa. The lentils were sorted to avoid damaged grains, stones and all other extraneous materials before milling (Perten Laboratory Mill 3600, Perten Instruments, Stockholm, Sweden) into flour. The wheat flour (WF) and lentils flour (LF) passed through a sieve (500 µm) while the dried lean beef was equally milled into flour.

Fettuccine preparation

The formulation used to prepare the fettuccine pastas is as follows: pasta made with 100% wheat flour (WFft), fettuccine pasta made with 95% wheat flour (361 g) and 5% lentils flour (19 g) (5% LFft), fettuccine pasta made with 95% wheat flour (361 g) and 5% lean beef flour (19 g) (5% LBFft), fettuccine pasta made with 90% wheat flour (342 g) and 10% lentils flour (38 g) (10% LFft), fettuccine pasta made with 90% wheat flour (342 g) and 10% lean beef flour (38 g) (10% LBFft). To the respective formulations, 160 g of warm water and 4 g of salt was added before the mixing and kneading for 5-10 min. The dough was rolled out into a thin pastry and cut into shape. Subsequent pasteurization treatment was done by conveying the fresh cut pasta through a chamber where steam circulates both over and under the product at 75 °C for 15 s and subsequent drying.

Proximate composition

The proximate compositions of the samples including moisture, crude protein, crude fat and crude fiber were determined (Adebisi *et al.*, 2017).

Amino acid (AA) compositions

Amino acid compositions of the samples were determined at the Agricultural Research Council (ARC)-Irene Analytical Research Laboratory, Pretoria, South Africa using high-performance liquid chromatography (HPLC) following the procedure of Adebisi *et al.* (2019). Briefly, 700 mg of each sample were hydrolysed using equal volume of 6 N HCl solution and an internal standard (α -amino- β -guanido propionic acid). The hydrolysate was transferred to an Eppendorf tube and centrifuged for 10 minutes at 300 rpm, after which the supernatant (protein hydrolysate) was filtered using a 0.45 µm filter. The protein hydrolysate was then dried under N₂ gas and derivatized using FMOc reagent and borate buffer. The resulting derivatized mixture was extracted with pentane and then analyzed on HPLC using fluorescence detectors (Schoeffel FS 970, Perkin-Elmer LS-4 and Shimadzu RF-530) at excitation and emission

wavelengths of 260 and 313 nm, respectively. The mobile phase was a mixture of HPLC grade acetonitrile, methanol and acetic acid (10:40:50, v/v/v) was used as the eluent and was varied linearly to acetonitrile: acetic (50:50, v/v) over 90 minutes. The oven temperature was kept at 40 °C while the gradient flow started at 3 minutes at 1.3 mL/min flow rate, which was later increased to 2 mL/min for 0.5 minutes at the end of the gradient. Amino acid standards (Merck, South Africa) were used to generate calibration curves and the concentration of the AAs in the samples were subsequently determined.

STATISTICAL ANALYSIS

All experiments were done in triplicates and results represent mean (average) of triplicate determinations, subsequently expressed as mean $\pm$ standard deviation (S.D). The data obtained were analyzed with ANOVA and SPSS Statistics 22 software (IBM, USA) was used to analyze the data with $p \leq 0.05$.

RESULTS AND DISCUSSION

Proximate compositions of the raw flours and derived fettuccine enhanced with LF and LBF are shown in Table 1. The moisture content of the WF, LF and LBF ranged from 12.90 – 14.98%, with the moisture of LBF significantly ($p \leq 0.05$) higher than that of WF and LF. A similar trend in the moisture content was also observed for the fettuccine samples, with fettuccine derived from 100% WF (WF_{ft}) having the highest value ($p \leq 0.05$) as compared to the enhanced fettuccine pastas. Similar observation was reported in spaghetti enriched with bean flour (Giubertiet *al.*, 2015). Moisture loss in enhanced pasta may be attributed to the reduction in gluten network produced, compared to 100% WF. Also, extended drying period leading to protracted separation of water-binding capacity at reduced gluten content may also be implicated (Ovando-Martinez *et al.*, 2009). Additional factors that may affect the moisture in fettuccine is the increase in fibre content and the amount of damaged starch that might be present as a result of processing (Giménez *et al.*, 2012) as well as reduced gluten network with addition of LF and LBF.

Table 1: Proximate compositions of the flours and enriched fettuccine

Sample	Fiber (%)	Fat (%)	Moisture (%)	Protein (%)
Flour				
WF	4.54 ^a $\pm$ 2.33	0.35 ^a $\pm$ 0.46	13.23 ^b $\pm$ 0.25	11.90 ^a $\pm$ 0.11
LF	6.91 ^c $\pm$ 0.67	0.64 ^b $\pm$ 0.39	12.90 ^a $\pm$ 1.46	22.49 ^b $\pm$ 0.08
LBF	4.76 ^b $\pm$ 1.17	1.15 ^c $\pm$ 0.39	14.98 ^c $\pm$ 0.62	25.63 ^c $\pm$ 0.18
Fettuccine				
WF _{ft}	3.95 ^a $\pm$ 0.85	0.27 ^a $\pm$ 0.12	13.07 ^e $\pm$ 1.03	11.83 ^a $\pm$ 0.14
5% LF _{ft}	5.03 ^c $\pm$ 0.93	0.27 ^a $\pm$ 0.12	11.60 ^b $\pm$ 1.73	12.39 ^b $\pm$ 0.06
5% LBF _{ft}	4.42 ^b $\pm$ 2.96	0.57 ^c $\pm$ 0.40	12.24 ^c $\pm$ 0.21	16.78 ^d $\pm$ 0.10
10% LF _{ft}	5.90 ^d $\pm$ 0.42	0.31 ^{ab} $\pm$ 0.21	10.93 ^a $\pm$ 2.62	12.72 ^c $\pm$ 0.09
10% LBF _{ft}	6.15 ^e $\pm$ 1.91	0.61 ^{cd} $\pm$ 0.02	12.72 ^d $\pm$ 0.60	23.22 ^e $\pm$ 0.08

LF (lentil flour); LBF (lean beef flour); WF (wheat flour); WF_{ft} (pasta made with 100% wheat flour); 5% LF_{ft} (fettuccine pasta made with 95% wheat flour and 5% lentils flour); 10% LF_{ft}

(fettuccine pasta made with 90% wheat flour and 10% lentils flour); 5% LBF_{ft} (fettuccine pasta made with 95% wheat flour and 5% lean beef flour); 10% LBF_{ft} (fettuccine pasta made with 90% wheat flour and 10% lean beef flour). Means with no common letters within a column significantly ($p \leq 0.05$) differ.

Crude protein content of the flours also ranged from 11.90 – 25.63%, with the LBF having the significantly ($p \leq 0.05$) highest crude protein value. As expected from the increase in protein content of the final products, a significant ($p \leq 0.05$) level of difference was recorded in all enhanced fettuccine samples (Table 1). Both beef and lentils are known to be good sources of protein and consequently, protein content of the enriched fettuccine samples were observed to increase with increasing addition of LF and LBF. Fettuccine enhanced with 5% lentils (5% LF_{ft}) had a protein content of 12.39%, which is higher than that of 100% WF, which was found to be significantly ($p \leq 0.05$) lower (11.83%). Likewise, a similar increase was observed with an increase in LBF addition and a 49% increase in crude protein recorded in the 10% LBF_{ft} sample. The initial crude protein levels in each flour and their respective AAs (Table 2) might have played a role in this noted increase.

The highest value for fat content was recorded for LBF and derived 10% LBF enhanced fettuccine (Table 1). Different beef samples may differ in fat content and fatty acid composition due to variations in fiber composition, age of the animal, feed composition, part of the animal's body from where the sample was obtained, amidst other factors. Beef is generally known to be high in fat and results obtained herein are expected. While the fat values were significantly ($p \leq 0.05$) lower for the LF and subsequent fettuccine samples (LF_{ft}), the general decrease in the fat content could be due to processing, particularly pasteurization and drying that might have influenced the crude fat content. It has been reported that fat fractions may be exuded with the moisture during heat treatments (Abraha *et al.*, 2018).

Amino acids (AA) are vital components required for metabolic activities, biosynthesis and neurotransmission among others, in the human body. They can be divided into essential and non-essential ones with the former being those the body cannot synthesize and must thus be obtained from food sources. With AAs being the building blocks of proteins, it is important for humans to consume complete proteins within their daily diets. In Table 2, WF has significantly ($p \leq 0.05$) higher contents of proline and glutamic acid than LF, which might be attributed to the role of both AAs serving as functional AAs and gluten proteins necessary for dough formation. LBF was observed to have the significantly ($p \leq 0.05$) highest value of AAs which further attests to the 'completeness' of meat protein (Ahmad *et al.*, 2018).

Different studies have been done on the improvement of pasta and it was reported that the addition of animal and plant proteins in pasta could increase insufficient essential amino acids. In agreement with previous studies and results on crude protein (Table 2), addition of these protein sources significantly ($p \leq 0.05$) increased most of the amino acids in the resultant fettuccine (Table 2). The control fettuccine made from 100% WF (WF_{ft}) had 0.19, 0.3 and 0.38 g/100g of methionine, lysine and threonine amino acids, respectively which were all

observed to increase significantly in the enriched products (Table 2). A 78% (approximately 5-fold) increase was recorded in 10% LBF_{ft} for lysine, an essential amino acid observed to be limiting in both WF and derived WF_{ft}.

Table 2: Amino acid composition(g/100g) of wheat, lentil, lean beef flours and derived fettuccine samples

Amino acids	Flour			Fettuccine				
	WF	LF	LBF	WF _{ft}	5% LF _{ft}	5% LBF _{ft}	10% LF _{ft}	10% LBF _{ft}
Essential AAs								
Histidine	0.24 ^a ±0.11	0.86 ^b ±0.02	2.96 ^c ±0.03	0.30 ^a ±0.02	0.34 ^b ±0.08	0.63 ^d ±0.07	0.36 ^{bc} ±0.09	0.73 ^e ±0.04
Isoleucine	0.38 ^a ±0.04	0.91 ^b ±0.08	2.24 ^c ±0.06	0.39 ^a ±0.05	0.40 ^a ±0.09	0.64 ^d ±0.04	0.43 ^b ±0.07	0.85 ^d ±0.10
Leucine	0.72 ^a ±0.12	1.55 ^b ±0.04	3.66 ^c ±0.02	0.73 ^a ±0.08	0.80 ^b ±0.12	1.19 ^e ±0.06	0.80 ^b ±0.01	1.58 ^d ±0.04
Lysine	0.26 ^a ±0.09	1.57 ^b ±0.02	4.80 ^c ±0.11	0.30 ^a ±0.11	0.32 ^b ±0.12	0.76 ^d ±0.09	0.38 ^c ±0.06	1.38 ^e ±0.01
Methionine	0.18 ^a ±0.05	0.17 ^a ±0.05	1.51 ^b ±0.07	0.19 ^{ab} ±0.12	0.20 ^{ab} ±0.02	0.40 ^c ±0.04	0.18 ^a ±0.01	0.52 ^d ±0.08
Phenylalanine	0.55 ^a ±0.02	1.12 ^b ±0.10	5.12 ^c ±0.08	0.56 ^a ±0.09	0.61 ^b ±0.04	0.89 ^e ±0.11	0.60 ^b ±0.16	0.97 ^d ±0.10
Threonine	0.36 ^a ±0.06	0.92 ^b ±0.09	2.38 ^c ±0.06	0.38 ^a ±0.14	0.41 ^b ±0.07	0.75 ^d ±0.09	0.43 ^c ±0.03	0.93 ^d ±0.02
Valine	0.44 ^a ±0.08	1.01 ^b ±0.09	2.15 ^c ±0.08	0.45 ^a ±0.06	0.47 ^b ±0.11	0.75 ^d ±0.10	0.49 ^c ±0.09	0.92 ^d ±0.05
Non-essential AAs								
Alanine	0.38 ^a ±0.11	1.01 ^b ±0.05	3.24 ^c ±0.09	0.38 ^a ±0.04	0.42 ^b ±0.08	0.68 ^d ±0.07	0.45 ^c ±0.06	1.13 ^e ±0.08
Arginine	0.60 ^a ±0.02	2.42 ^b ±0.09	3.39 ^c ±0.12	0.59 ^a ±0.14	0.66 ^b ±0.11	1.29 ^d ±0.08	0.74 ^c ±0.03	1.53 ^e ±0.07
Aspartic acid	0.52 ^a ±0.04	2.81 ^b ±0.01	4.66 ^c ±0.07	0.51 ^a ±0.01	0.49 ^b ±0.08	0.42 ^a ±0.06	0.70 ^d ±0.02	1.73 ^e ±0.08
Glutamic acid	4.27 ^b ±0.10	4.08 ^a ±0.13	7.95 ^c ±0.07	4.16 ^b ±0.07	4.23 ^c ±0.09	3.07 ^a ±0.05	4.23 ^c ±0.11	5.74 ^d ±0.06
Glycine	0.45 ^a ±0.09	0.99 ^b ±0.11	2.91 ^c ±0.10	0.44 ^a ±0.06	0.49 ^b ±0.05	0.92 ^d ±0.02	0.49 ^b ±0.04	1.00 ^d ±0.12
HO-Proline	-	-	0.62 ^a ±0.10	-	0.01 ^a ±0	0.01 ^a ±0.01	0.01 ^a ±0	0.08 ^b ±0.04
Proline	1.25 ^b ±0.01	0.89 ^a ±0.08	2.03 ^c ±0.11	1.21 ^a ±0.11	1.31 ^b ±0.02	1.81 ^d ±0.02	1.21 ^a ±0.06	1.51 ^c ±0.01
Serine	0.64 ^a ±0.12	1.31 ^b ±0.09	2.09 ^c ±0.05	0.63 ^a ±0.07	0.72 ^c ±0.04	1.16 ^e ±0.12	0.70 ^b ±0.01	1.12 ^d ±0.06
Tyrosine	0.35 ^a ±0.12	0.67 ^b ±0.07	2.34 ^c ±0.08	0.47 ^c ±0.11	0.40 ^a ±0.06	0.47 ^c ±0.10	0.43 ^b ±0.02	0.73 ^d ±0.07

g/100 g – gram/100grams; LF (lentil flour); LBF (lean beef flour); WF (wheat flour); WF_{ft} (pasta made with 100% wheat flour); 5% LF_{ft} (fettuccine pasta made with 95% wheat flour and 5% lentils flour); 10% LF_{ft} (fettuccine pasta made with 90% wheat flour and 10% lentils flour); 5% LBF_{ft} (fettuccine pasta made with 95% wheat flour and 5% lean beef flour); 10% LBF_{ft} (fettuccine pasta made with 90% wheat flour and 10% lean beef flour). Means with no common letters within a row significantly ($p \leq 0.05$) differ.

CONCLUSION

Insight into the enhancement of fettuccine as a complete protein was provided in this study. Enhancement of pasta with both lentil and lean beef flours increased both the essential amino acids and the protein content of the fettuccine. Increasing amount of substitution also increased the nutritional constituents. It can thus be suggested that 10% substitution of both beef and lentil would be best applicable for consumption. For future studies, it is recommended that amino acids (cysteine and tryptophan) that were not investigated in this study should be analysed. Mineral elements, carbohydrate, ash, energy contents and fatty acids in the enhanced pasta can also be investigated, as well as cooking losses and potential health beneficial constituents of the products.

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QUALITIES OF CHEESE ANALOGUE AS AFFECTED BY BAMBARA AND WEST AFRICAN DWARF GOAT MILKS MIXTURES

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ABSTRACT

Cheese analogues (CA) are products made by blending individual constituents, including non-dairy ingredients, to produce a cheese-like product that satisfies a certain need. The physicochemical parameters of CA processed from the mixture of bambara milk using Simplex Lattice Design of Design Expert were examined. Textural properties were cohesiveness 0.64 N and chewiness 26.62 N for 100% West African Dwarf (WAD). The adhesiveness, 0.62 N, stickiness, 0.50 and springiness, 0.80 m were for CA from cream-colour bambara milk (BCM). Hardness 96.57 N, adhesiveness 1.55 N, stringiness 7.51 m and stickiness -23.00 were for CA from brown-colour bambara milk (BCM). Highest values of textural parameters examined were found in 100% WAD cheese analogue (cohesiveness 0.64 and chewiness 26.62 N) and 100% cream-coloured bambara CA (adhesiveness, 0.62 N, stickiness, 0.50 and springiness, 0.80 m). On the contrary, the CA made from 100% BCM had no appreciable highest values in any of the texture parameters tested. Nevertheless, some of the highest values (hardness 96.57 N, adhesiveness 1.55 N, stringiness 7.51 m and stickiness -23.00) were observed in mixtures of 75:25 of BCM/WAD milks. Effects of milk mixtures on hardness, adhesives, stringiness and stickiness of the cheese analogues samples were significantly ($p \leq 0.05$) different.

Key words: brown-coloured Bambara, cream-coloured Bambara, West African Dwarf (WAD), cheese analogue.

1.0 Introduction

Bambara groundnut, (*Vigna subterranea* (L) Verdc.) originated from West Africa and it has been cultivated as one of the most important pulses in tropical Africa since the seventeenth century. It is also grown in other Africa countries such as Senegal, Kenya and South Africa (Atiku *et al.*, 2004). Bambara groundnut is now found in many parts of South America, Central America, and Oceania. Goli (1997) reported that bambara groundnut contains about 63% carbohydrate, 19% protein, and 6.5% oil and is consumed in different forms. Atiku *et al.* (2004) reported that the seed of bambara groundnut can be used for baby food, consumption as adult food, for industrial production and for animal feed. Broughton *et al.* (1993) noted that the milk prepared from bambara groundnut gave flavour which was much preferred to that of milk from cowpea, pigeon pea and soya bean.

Recently, there is a global increase in goat milk consumption, as consumers recognize the advantage of goat milk especially in developed nations of the world. There is awareness of high nutritional composition of goat milk, enhancing its quality for human consumption. West African Dwarf Goat is a multi-purpose goat breed and mostly raised for meat and milk production. Goat milk is mostly preferred substitute to cow milk for people who suffer from allergies from cow milk (Anaeto *et al.*, 2010). In many developing countries, there is a growing awareness about the fact that goats are the most efficient animals for milk production. Nutritional composition of milk varies with breeds of goats. Basically, goat milk consists of protein, fat, minerals, lactose, vitamins, and enzymes. It has more fat, protein, ash and less lactose than cow milk.

Cheese analogue is also known as 'imitation cheese' or 'cheese substitute'. These are substitutes of cheese that are produced to mimic the taste and appearance of the real cheese. Common ingredients in cheese analogue production includes fat, milk proteins (casein, caseinates, whey), vegetable proteins, salts, starch, binder, stabilizers, acidifying agents, flavour enhancers, colouring agent, preservatives, minerals and vitamins. Casein derivatives are commonly used in production of cheese analogues; this is due to their nutritive, textural, storage and functional properties such as spreadability, firmness and elasticity. One of the functions of casein as ingredient in cheese analogue processing is to improve the chewiness of cheese and to fix the melting feature of cheese. Cheese analogues are classified into three based on its textural and functional characteristics, the classification include; Dairy cheese analogues: those that are produced through milk e.g. casein, caseinates and fats, Partial dairy cheese analogue: those produced through partial milk e.g. casein, caseinates, milk, fat and soya oil and Synthetic cheese analogues: those produced through components other than milk e.g. soya, protein, soya oil. Cheese analogue demonstrates better properties during storage in terms of fat leakage, texture thickness and slice-ability. The objective of this study was to determine the effects of ingredients (Bambara milk and West African Dwarf goat milk) combination on textural attributes of cheese analogues.

2.0 MATERIALS AND METHODS

2.1 Sample collection

Bambara groundnut containing different varieties of seeds were purchased from Ogbete market in Enugu, Enugu state, Nigeria. Two landraces/varieties of BGN were used for this research; cream-coloured bambara groundnut seed and brown-coloured bambara groundnut seeds. The two varieties of bambara groundnut seeds were subjected to processing methods described by Plahar (2002) with slight modification. Fresh raw milk of West African dwarf (WAD) goat was collected aseptically from a small-holder dairy goat research farm in Department of Animal Physiology, College of Animal Science and Livestock Production (COLANIM) farm, Directorate of University Farms (DUFARMS) at Federal University of Agriculture, Abeokuta, Nigeria. Cow milk (for control experiment) was collected from a local farm in Lafenwa Abeokuta, Ogun State Nigeria.

2.2 Preparation of samples

Optimized bambara flour samples (from the two varieties) were rehydrated to produce milk using the optimized temperature and time as reported by Murevanhema and Jideani (2014). The flour was hydrolyzed (1:10) with distilled water and allowed to hydrate in water bath for 2 h at 25 °C. The slurry was filtered through muslin cloth with mesh of 707 µm (No 25) folded four times to yield bambara juice. The juice was then homogenized for 5 min at 1050g. It was allowed to settle for 5 min and decanted carefully into 500 mL bottle. The bambara juice was then autoclaved at 121 °C for 15 minutes to produce bambara milk.

Cheese analogue was prepared in batches according to the method described by Adetunji and Babalobi (2011) with some modifications. About 100 mL of the combined milk mixture was poured into a beaker (Pyrex) and pasteurized at 85°C for 5 min. Approximately 0.04 g CaCl₂ was added and it was allowed to boil for 2 min after which 10 mL of the coagulant (lemon juice: steeped corn liquor mixture 1:5) was added. The mixture was heated slowly with intermittent stirring until it reached the boiling point. It was then kept at boiling point (~95°C) until it coagulated and there was visible separation of curd and whey (in 2-5 min). The curd was allowed to boil for another 5 min after which the beaker was then removed from the heating source and the curds and whey were ladled into a sterile sieve cloth, to facilitate whey drainage. Weight of cheese and volume of the whey were recorded. The cheese was then shaped in rubber-made ice cube container to give the cheese analogue its characteristic shape and size

2.3 Texture analysis

Instrumental texture profile analysis (TPA) of cheese analogue samples were performed using a Texture Analyser (TVT 6700, Preten Instruments, Australia) with a load cell of 25 kg and a cylindrical-shaped probe (45 mm of diameter SN:673045). The TVT 6700 applies controlled conditions of stress or strain to food and other samples to measure a complete texture profile. It accurately measures compressive and tensile force and position over time using standard test modes including single and multiple cycle compression, tensile strength, compress-and-hold, extend-and-hold, fracturability and spring-back to describe product texture. Testing was carried out after the samples had been equilibrated to a standard temperature of 20 ± 1°C. The probe moved from its starting position as defined by sample height + starting distance from the sample (25 mm + 5.00). The probe then moved down to compress the sample at the initial speed of 2.0 m/s until trigger force of 0.98 N was reached. The probe continued moving at the test speed of 3.0 m/s until it reached compressing position of 10 mm setting. The probe changed direction and moved at the retract speed of 3.00 m/s until the original height of the sample was reached. Two consecutive compressions were performed automatically. The waiting time between one cycle and another was set at 15 s. From the force curve versus time, these mechanical properties were determined: hardness (N) (firmness/softness), adhesiveness (or stickiness), springiness (elasticity), cohesiveness, resilience, chewiness, gumminess, stringiness/shortness and stickiness. Data was captured as a graph and stored in a tabular data base for analysis and export to spread sheet programmes.

2.4 Statistical analysis

All data were analysed using Design Expert Software (Stat Ease Inc. Software) Version 10.0.7 and SPSS Version 17 to determine significant effect of the independent variables on responses at both 5% and 1% level.

3.0 Results and discussion

3.1 Effects of milk mixtures on some physicochemical characteristics of cheese analogue from bambara milk and west African dwarf goat milks

Percentage yield of cheese analogue increased from 9.78% to 19.66%. Whiteness (L^* values), a^* and b^* values, total titratable acidity, moisture content, crude fat, crude protein and total ash of the cheese analogues were in the range of 79.76 to 93.89, -2.65 to 2.64, 13.59 to 17.08, 0.25 - 0.39%, 51.91 - 72.70%, 6.35 - 12.90%, 14.74 - 19.42% and 0.76 - 1.92%, respectively. Highest values of percentage yield, total titratable acidity, crude fat, crude protein and total ash were found in cheese analogue made with 100% West African dwarf milk.

The results (Table 1) of physicochemical analyses of cheese analogue samples made from mixtures of brown-coloured (seed) bambara milk and West African dwarf milk. From the result, the percentage yield ranged between 9.78 and 20.07%. The L^* value (whiteness), a^* value (blueness) and b^* value (yellowness) of the cheese analogue increased from 81.45-92.13, -3.00 -2.22 and 12.57 - 15.91, respectively. The values of total titratable acidity, moisture, crude fat, crude protein and total ash contents in cheese analogue samples were 0.18 – 0.37, 52.63 – 74.60%, 6.85 -12.19%, 14.99 – 19.27% and 0.57 – 1.86%, respectively. It was also observed from Table 16 that the highest values of percentage yield, L^* value, total titratable acidity, crude fat, crude protein and total ash were found in the cheese analogue made from 100% WAD milk. Cheese analogue processed from 100% bambara milks had highest a^* colour values (blueness) and moisture content (Table 1).

3.2 Effects of Milk Mixtures on Textural Properties of Cheese Analogue from Bambara and West African Dwarf Goat Milks

With respect to texture qualities of cheese analogues, the results of this experiment presented in table 1 showed that there were significant ($p < 0.5$) differences in textural parameters obtained from the samples except for hardness, adhesiveness, springiness, stickiness of cream-coloured bambara milk cheese analogue and stickiness of brown-coloured bambara milk cheese analogue. However, extreme values of textural properties were found in either cheese analogue made from 100% cream-coloured bambara milk or 100% WAD goat milk. This indicated that composition of the two varieties of bambara groundnut were significantly different from each other, as expected. The difference in texture could be as a result of variance in the fatty acid composition of different types of milks in the mixture. The cheese analogue with more content of bambara milk tend to have the highest values of hardness, stringiness, and stickiness. Lower values for cheese analogues processed from mixtures with more content of WAD milk could

be as a result of the fact that goat milk coagulates earlier (than cow milk), hence they are characterised with less firm cheese (coagulum) than cow milk cheese.

Table 1: Mean values of textural properties of WAD and Bambara milk

Milk mixture		Cream-bambara milk/WAD cheese analogue								Brown-bambara milk/WAD cheese analogue							
BM	WM	HD (N)	CHS *	AD (N)	SP (m)	CH W (N)	ST	SK	GM (N)	HD (N)	CHS *	AD (N)	SP (m)	CH W (N)	ST	SK	GM (N)
0	1	54.77	0.64	0.44	0.77	26.44	4.75	-24.5	33.19	54.75	0.62	0.45	0.79	26.62	4.69	24.50	33.81
0.25	0.75	30.33	0.46	0.49	0.63	18.9	5.93	30.00	24.22	55.63	0.55	0.34	0.77	23.99	3.12	27.00	31.14
0.5	0.5	61.61	0.50	0.58	0.74	21.81	5.04	27.50	30.67	65.00	0.52	0.63	0.68	23.32	5.31	27.00	34.05
0.75	0.25	28.90	0.60	0.37	0.74	13.18	4.26	25.00	17.73	96.57	0.24	1.55	0.30	7.07	7.51	23.00	23.84
1	0	76.66	0.56	0.62	0.80	11.99	4.96	0.50	14.89	33.71	0.43	1.49	0.47	6.70	6.98	24.50	14.29

M= bambara milk, WM= West African dwarf goat milk, HD = hardness (N), CHS= cohesiveness, AD = adhesiveness, SP = springiness, CHW= chewiness, ST = stinginess, SK = stickiness, GM = gumminess, N = Newton, m = meter, * - No unit

3.2 Discussion

The results of quality parameters of cheese analogue obtained showed that the contents, proportion and compositions of West African dwarf (WAD) goat-bambara milk mixtures determined milk coagulation, cheese analogue yields and certain quality compositions. Casein family (82%) of milk protein contains phosphorus and it coagulates at pH 4.6 leaving the serum remaining as solution. Proportion of short/medium chain fatty acid as well as content and behaviour of different types of casein (α , β or κ) in milk mixtures determined quality characteristics of cheese analogues (Vyhmerster *et al.*, 2019).

Textural characteristics decreased whenever the rate of hydrolysis of protein in the milk mixture increased during processing. However, increase in casein contents in the milk mixture produced a positive effect. Likewise, milk mixture with high pH and moisture contents produced cheese analogue with less firmness and elasticity, but better spreadability (Lee *et al.*, 2015).

Texture profile analysis of the cheese analogues were carried out to mimic mouth's biting attributes when chewed. This often determines sensory expectation of the food sample. Cheese hardness is also affected by lipid/protein ratio, fat type, stirring speed casein composition of milk mixture, syneresis rate, moisture retention and percentage yield (Abd El-Gawad and Ahmed, 2011). To process cheese analogue with better arrangement of casein particles in gel network, pre-heating, high inoculation temperature and fast rates of acidification are

recommended. Just like other legumes, 100% milk-like extract from bambara groundnut may not be used to process rubbery-type cheese analogue like the usual African soft cheese (unripen). Nevertheless, the cheese analogue had acceptable texture after combining with as goat milk at optimum ratio.

Conclusion

The WAD-bambara milk mixture contents, proportions and ingredients chemical compositions have effects on milk coagulation, cheese analogue yield and textural properties. The study has identified that other factors influenced some of the cheese qualities (protein, moisture content, yield, redness and yellowness) apart from milk mixture used in processing. Textural properties of cheese analogue made from bambara milk and WAD goat milk were extremely different. Hence, there were noticeable differences in textural properties (hardness, stringiness and stickiness) as the milk mixture combination varied.

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ANTIMICROBIAL ACTIVITY AND PRESERVATIVE POTENTIALS OF BACTERIOCIN FROM LACTIC ACID BACTERIA ISOLATES ON BEEF

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Abstract

Preservation and inhibition of microbial growth in food using bio-friendly substances has increasingly gained global attention in the food industry. In this study, the antimicrobial activity of bacteriocin against selected pathogenic bacteria and its bio preservative efficacy on homogenized beef was evaluated. The antimicrobial activity of the isolates was determined by growth inhibition test against *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Clostridium botulinum*. The bio preservative activity of the isolates on beef was also determined using plate count method. The result revealed higher zone of inhibition on gram positive bacteria isolates when compared to the gram negative bacteria. The antimicrobial activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa* when compared to *Escherichia coli* and *Samonella typhi*. The results also revealed that in the overall effectiveness of the bacteriocin produced to inhibit the selected pathogenic isolates, the most effective organisms that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. The effect of bacteriocin concentration on bacteria count of homogenized beef sample revealed that the control sample had higher microbial count when compared with the other samples.

Keywords: Bacteriocin, Antimicrobial activity.

1.0 INTRODUCTION

Bacteriocins are ribosomal-synthesized antimicrobial peptides that inhibit the growth of pathogenic bacteria. The most studied bacteriocin-producing microorganisms are lactic acid bacteria (LAB), as they have great potential application in food biopreservation.

Biopreservation is an important approach to maintain the microbiological quality and safety of meat and meat products. This technique is used to extend food shelf-life through the application of a protective microbiota, for example, the use of LAB with their antibacterial properties, such as the production of bacteriocins (Oliveira *et al.*, 2012). The LAB-producing bacteriocins have been widely studied, with the emphasis on those derived from milk and dairy products. Bacteriocins are proteinaceous agents which are rapidly digested by proteases in the human digestive tract and are active at low pH and has caught the attention of food scientists as a natural food preservative with potential antimicrobial activity that could lead to improvement in shelf life of food and inhibition of pathogenic bacteria. Bacteriocins produced by LAB have been efficiently used in bovine and poultry carcasses and fresh meat (Barboza *et al.*, 2002)

This study aims to explore the antibacterial activity of crude bacteriocin from *Lactobacillus jensenii* JV-V16, *Lactobacillus crispatus* STI, *Lactobacillus sakei* and *Lactobacillus salivarius* against selected pathogenic bacteria.

2.0 MATERIALS AND METHODS

2.1 Isolation and identification of Lactic acid Bacteria from fresh Cow milk

Raw cow milk was aseptically transferred into sterile containers from Jimba-oja kwara state, stored at 4°C and transported to central research laboratory University of Ilorin. Two milliliter sample of milk was collected aseptically and serially diluted in peptonated saline solution and plated on MRS agar supplemented with 50mg/litre Natamycin to rule out yeast contamination (De man *et al.*, 1960). The plates were incubated at 37°C for 48h and the culture was purified by repeated streaking.

2.2 Production of Bacteriocin from Lactic Acid Bacteria Isolate

LAB isolates was grown on MRS broth and was incubated for 37°C for 48h. After which it was centrifuged at 5000rpm for 10min and the cells was separated. The cell free supernatant was used as crude bacteriocin extracts (Ogunbanwo *et al.*, 2003)

2.3 Screening of Bacteriocin for Antimicrobial Activity

Antimicrobial activity of bacteriocin of LAB isolates from fresh cow milk was tested against pathogenic organisms (Clinical isolates obtained from the laboratory) using well diffusion method under aerobic conditions. Agar plate was inoculated with of 500 µl each microorganisms namely *Lactobacillus jensenii* JV-V16, *Lactobacillus crispatus* STI, *Lactobacillus sakei* and *Lactobacillus salivarius* after growing them in nutrient broth and diluting appropriately. The

inhibitory activity against the pathogenic microorganism was tested on plate containing Mueller Hilton Agar plate and 150µl of cell free supernatant (Crude bacteriocin) of isolated strain was added into each well. Plates were incubated at 37°C for 24 hour. The antimicrobial activity was determined by measuring the diameter of the inhibition zones around the wells.

2.2 Biopreservative Efficiency of Bacteriocin on Beef

The food product (beef) was aseptically obtained from ipata market in Ilorin and immediately conveyed to the laboratory where it was homogenized by blending (40rpm) for 30secs and serially diluted at 10^{-6} . A portion (control) of homogenized beef was examined for total plate count (TPC) at an incubation temperature of 37°C for 24h bacteriocin extracts was added to the other portion of the homogenized beef sample at different concentrations (0.5mg/ml, 1mg/ml, 2mg/ml, and 4mg/ml). The colony count of the bacteriocin mixed samples and the control sample were recorded.

3.0 RESULTS AND DISCUSSION

3.1 Antimicrobial Activity of Crude Bacteriocin produced from Lactic Acid Bacterial on Some Bacterial Isolates

The result of the Antimicrobial activity of crude Bacteriocin produced from Lactic Acid Bacterial on some bacterial isolates are presented in Figure 1. Higher zone of inhibition was observed in gram positive bacteria isolates when compared with the gram negative organisms. The result also showed that *Lactobacillus jensenii* JV-V16 was more effective on *Staphylococcus aureus* and *Clostridium botulinum* when compared to others. Also, *Listera monocytogenes* exhibited higher zone of inhibition on addition of bacteriocin produced from *Lactobacillus crispatus* when compared to *Staphylococcus aureus* and *Clostridium botulinum*. The antimicrobial activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa*, when compared to *Escherichia coli* and *Samonellatyphi*. This showed zone of inhibition on addition of bacteriocin produced from *Lactobacillus jensenii* JV-V16.

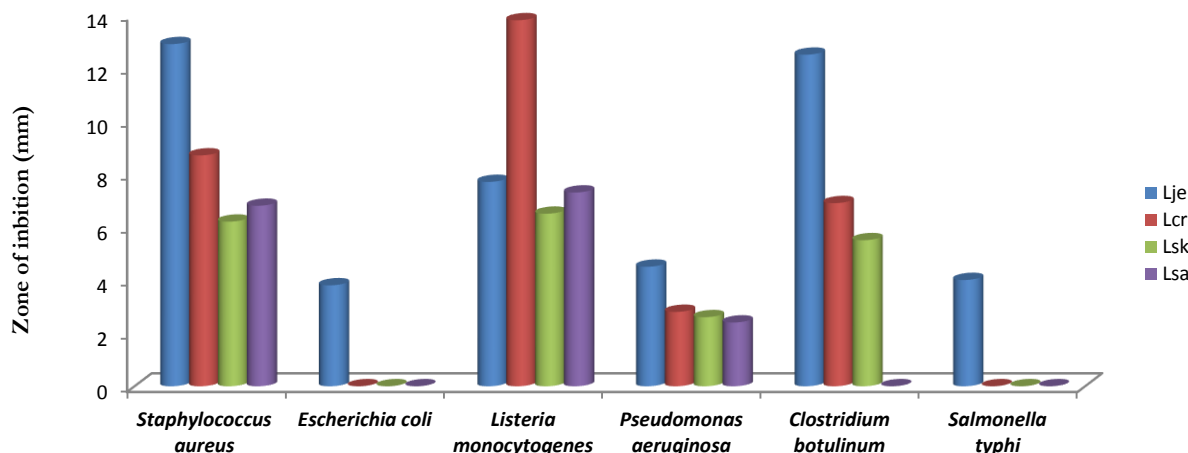


Figure 1: Antimicrobial Activity of Crude Bacteriocin produced from Lactic Acid Bacteria on Some Bacterial isolates

LJe= *Lactobacillus jensenii* V-V16, Lcr= *Lactobacillus crispatus* ST1, Lsk= *Lactobacillus sakei*, Lsa= *Lactobacillus salivarius*

The bacteriocin from the isolated Lactobacilli appears to have significant inhibition against the tested organisms except for *E. coli* and *S. typhi* which resisted the bacteriocin from *L. crispatus*, *L. sakei* and *L. salivarius*. In the order of the overall effectiveness of the bacteriocin to inhibit the pathogenic selected isolates, the most effective bacteriocin that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. Several studies reported varying output in the use of *L. salivarius* in various treatment study of human ailments and diseases either as probiotics or inhibitory ability via bacteriocin (Iwamoto *et al.*, 2010), however, *L. salivarius* was least active in this study. In contrary to this result, the antibacterial and anti-inflammatory capability of bacteriocin against the causative organism of acne i.e. *Propionibacterium acnes* was impressive due to its ability to inhibit the release of chemokine Interleukin-8 (IL-8) in comparison with previous topical and oral antibiotics (Deidda *et al.*, 2018). Furthermore, in a research to fight food borne illness caused by *L. monocytogenes*, Corr *et al.* (2007) reported that the bacteriocin produced labelled Abp118 exhibited a direct antagonism against the pathogen in the infected mice. The outcome of this study presented in figure 1 also supports the inhibitory capability of bacteriocin produced by *L. salivarius* against *L. monocytogenes*. Compounds from *Lactobacillus jensenii* and *crispatus* have been reported to possess antimicrobial properties. This is also corroborates to the result of this study where the bacteriocin inhibitory effect was evident. Wang *et al.* (2017) reported similar results while working on strategies to minimize adverse effect of salinity on aerobic granular sludge.

Additionally, Mobarez *et al.* (2008) reported the active inhibition of bacteriocin-like compounds from *Lactobacillus* spp against *P. aeruginosa* and *S. aureus*.

3.2 Effect of bacteriocin concentration on bacterial count of homogenized Beef

The effect of bacteriocin concentration on bacteria counts of homogenized beef samples are shown in figure 2. The result showed that the control sample had higher microbial count (5×10^6 cfu/g) when compared with the other samples. The bacterial count was observed to decrease with increase in bacteriocin concentration.

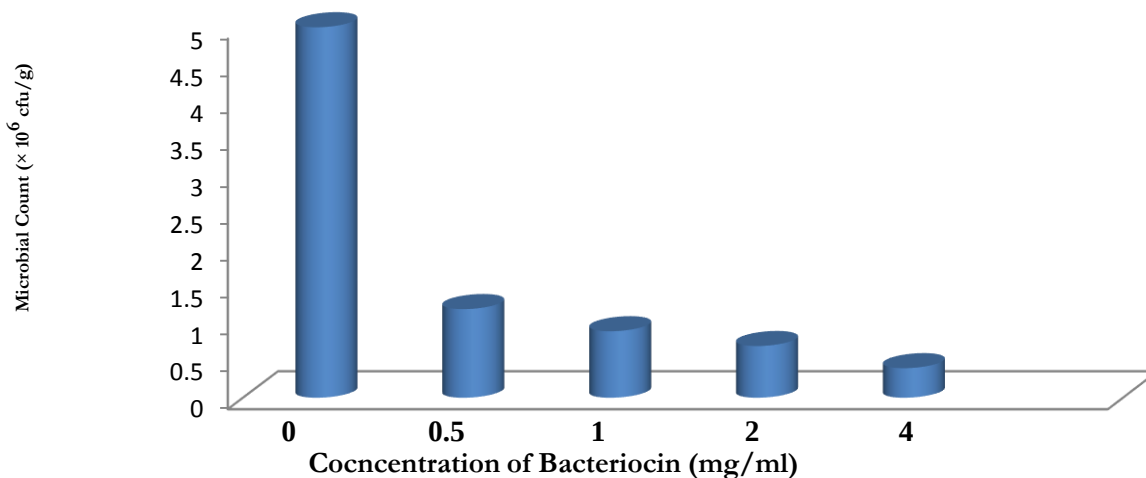


Figure 2: Effect of bacteriocin concentration on bacterial count of homogenized Meat Sample

Bio-preservation is an important approach to maintain the microbiological quality and safety of meat and meat products. This technique is used to extend food shelf-life through the application of a protective microbiota such as the use of lactic acid bacteria (LAB) with their antibacterial properties and the production of bacteriocins. Bacteriocins are small peptides or bioactive proteins, ribosomally synthesized by Gram-positive and Gram-negative bacteria and extracellularly released. The antimicrobial property exhibited by bacteriocin on the homogenized meat sample justifies the biotechnological potential of bacteriocins. In contrary to the result obtained in this study, Cho *et al.* (2010) reported a failure of bacteriocin of *L. plantarium* BFE5092 in turkey meat, while in the meat industries, pediocin PA-1 or this bacteriocin-producing culture is known to reduce the growth of spoilage microorganisms during storage.

4.0 CONCLUSION

The antimicrobial activity of crude Bacteriocin produced from Lactic Acid Bacterial on some bacterial isolates and the effect of bacteriocin concentration on bacteria count of homogenized beef sample are revealed in this study. The study revealed a higher zone of inhibition in gram positive bacteria isolates when compared with the gram negative organisms. The antimicrobial

activity exhibited by the gram-negative organism showed that all bacteriocin produced was at higher zone of inhibition on *Pseudomonas aeruginosa* when compared to *Escherichia coli* and *Salmonella typhi*. The study also revealed that in the order of the overall effectiveness of the bacteriocin to inhibit the pathogenic selected isolates, the most effective bacteriocin that was recorded in this study was *L. jensenii*, followed by *L. crispatus*, *L. sakei* and then *L. salivarius*. The effect of bacteriocin concentration on bacteria count of homogenized beef samples revealed that the control sample had higher microbial count when compared with the other samples. The study revealed that the bacteria count decreased with increase in bacteriocin concentration. It is therefore concluded that crude Bacteriocin produced from Lactic Acid Bacteria had significant inhibition against the tested organisms. It is also concluded that it effectively reduced the bacteria count in beef.

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MICROBIAL LOAD OF SELECTED SMOKED PERIWINKLE (*Tympanotonus Fuscatus*) AND OYSTER (*Crassostergasar*) SOLD IN MILE THREE (3) MARKET OF RIVERS STATE , NIGERIA .

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Abstract

The present study investigated the concentration of microbial concentration in oyster, periwinkle , in Mile 3 market, Port Harcourt ,Rivers State. There were decreases in the Total heterotrophic bacterial count, (THBC)(0.40×10^5 cfu/ml) in oyster while periwinkle had an increase of 6.77×10^5 cfu/ml . There was an increase in hydrocarbon utilizing bacteria(HUBC) and total fecal count (TFC) in oyster(7.15×10^5 cfu/ml) and in periwinkle it decreased to 5.78 .Vibrio count decreased in both .This could be as a result of high degree of exploration activities and human population in the oil producing communities around this creek. The waste water released into this creek from most of the crude oil-processing More so, the concentration of micro- organisms is very important in assessing the quality of these organisms because toxicity depends on the amount of the contaminant absorbed by these organisms which will affect the health of humans that depend on them It became necessary to determine the microbial concentration of tissues of mangrove oysters (*Crassostergasar*) and Periwinkle *TympanotonusFuscatus*for its safety .

Keywords: Microbial Load, Mangrove oysters (*Crassostergasar*), Periwinkle *TympanotonusFuscatus*,

Introduction

Oyster and periwinkle have the ability to accumulate contaminants such as heavy metals, micro-organisms and polycyclic aromatic hydrocarbons in the environment. The ingestion of these contaminants affect the health of humans who depend on these organisms for food (1). Hence, they constitute major source of protein to rural communities of Rivers State. However, periwinkles and oysters are of commercial value because most people use it in soups and as a delicacy. Therefore, consumption of raw, smoked or under cooked shellfish is an important source of food borne poisoning mostly epidemic and sometimes sporadic. These include typhoid fever, salmonellosis, shigellosis, campylobacteriosis, cholera, gastroenteritis and hepatitis .

However if the concentration of these organisms are higher than the permissible limits, they may cause diseases that are infectious .This makes the assessment of microbial load is very important for public health concern

More so, the bio-availability of the concentration of this micro- organisms is very important in assessing the quality of these organisms because toxicity depends on the amount of the contaminant absorbed by these organisms which will affect the health of humans that depend on them (2). This present study therefore aims at assessing the safety of these shellfish in Mile 3 market of Rivers State ,Nigeria .

Materials and Methods

Periwinkle and Oyster sample were chosen for this work based on their availability all year round. . They were tied up tightly in polytene bag to avoid cross contaminated and were subjected to microbiological analysis at department of microbiology laboratory ,Federal University Otuoke, Bayelsa ..The following analysis were carried out according to the standard method of AOAC International (3) total heterotrophic bacterial count, hydrocarbon utilizing bacteria count, total fungal counts, hydrocarbon utilizing fungal counts, faecal coliform count, Vibrio Count (all in $\times 10^5 \text{Cfu/g}$.)Data were analyzed using IBM SPSS

Inc. software (version 21.0). All experiment was conducted in duplicate and mean values were compared using one-way ANOVA

Result and Discussion

Table 1. Microbial load of Oyster and Periwinkle sold at Mile 3 market ,Port Harcourt

Parameters	Oyster	Periwinkle
THBC	0.40±0.03 ^d	6.77±0.28 ^c
HUBC	7.15±0.41 ^c	5.78±0.18 ^d
TFC	5.09±0.07 ^c	0.53±0.02 ^d
HUFC	0.37±0.02 ^c	1.25±0.10 ^d
FCC	1.12±0.11 ^c	0.92±0.09 ^c
VC	0.74±0.11 ^c	0.89±0.15 ^d

Means with different superscripts in the same column are significant $p < 0.05$

Key: THBC - Total heterotrophic bacterial count, HUBC - Hydrocarbon utilizing bacteria count, TFC - Total fungal counts, HUFC - Hydrocarbon utilizing fungal counts, FCC - Faecal coliform count, VC - Vibrio Count (all in $\times 10^5 \text{Cfu/g}$).

The hydrocarbon utilizing fungal count(HUFC) for oyster recorded $0.37 \times 10^5 \text{CFU/g}$. Total hydrocarbon bacteria count, (THBC) was $0.40 \times 10^5 \text{CFU/g}$ and vibrio count (VC) were $0.74 \times 10^5 \text{CFU/g}$. This was lower in concentration than periwinkle. The total feecal count (TFC) $0.37 \times 10^5 \text{CFU/g}$ and hydrocarbon utilizing bacteria count (HUBC) $0.74 \times 10^5 \text{CFU/g}$ in oyster were also higher than in periwinkle sample. Okereke *et al.* (2017) reported higher values of HUB from two of the selected sites (Okwujagu and Slaughter) for oysters compared to the lower values reported in our study on periwinkles. The high concentration of the total coliform count could also be as a result of occasional rainfall in their habitat whose run-off carries

some load of debris, faecal and organic matter into the creeks resulting in higher values of total coliform count bacteria as recorded in this location. The mangrove oysters (*Crassostrea*) are filter feeders, capable of accumulating micro-organisms in high concentration. Most shellfish respond to changes in concentrations of contaminants in water and they integrate contaminants from the water column over time (4). This confirms the present study. Oysters could also be used as vectors for indicator of water quality since they harbor micro-organisms. The concentrations of this microbial load could be as a result of oyster having the ability to accumulate contaminants such as heavy metals, micro-organisms and polycyclic aromatic hydrocarbons in the environment.

The increase in the bacterial population is also attributed to the stimulatory effect of additional carbon and energy sources in the form of effluents, and crude oil, which leads to an enrichment of the oil degrading microbial population, which is made possible by hydrocarbon utilizing bacteria (5).

Conclusion

There were increases in the microbial populations in oyster sample than in periwinkle. Shellfish are very good source of protein with local and international value. Therefore, the safety of this seafood has to be ensured by monitoring and evaluation of each processed product before approval for consumption.

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CHAPTER 2

CEREALS, COMPOSITE FLOURS AND BAKED PRODUCTS

**COMPARATIVE ANALYSIS OF THE SENSORY CHARACTERISTICS OF
WHOLE-WHEAT TIGERNUT BISCUITS BAKED WITH SHORTENINGS-
FROM MARGARINE AND AVOCADO PASTE.**

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Abstract

Biscuits are convenient snacks produced from wheat flour. Giving its wide consumption, the advocacy for its development from entirely home grown crops or as a composite with wheat flour has been recommended. This study was aimed at comparing the sensory attributes of whole-wheat Tigernut biscuits baked with avocado paste as a fat replacer to those baked with margarine. Composite flour was obtained by blending whole tigernut flour with wheat flour at three different levels; 10, 20 and 30% respectively. The composite flour was divided into two parts. The recipe for the first parts (T10, T20, and T30) and the control sample (T00) were formulated, prepared into dough and baked with margarine (100%) into biscuits using rubbing in method, while in the second part (AT10, AT20, and AT30), the margarine were replaced with avocado paste (100%). Sensory properties and overall acceptability of Biscuits baked with margarine were not adversely affected while biscuits baked with avocado paste was acceptable up to 10% whole tigernut flour substitution. Avocado paste as a fat replacer showed promising prospects and should be optimized and exploited as a healthier dietary source to enrich bakery products like biscuits in Nigeria.

Keywords: Biscuit, Tiger Nut, Wheat, Avocado, Sensory properties.

Introduction

Biscuit is a snack mainly consumed because of its cheap cost, easy to use and its availability in massive variety of shapes, sizes, tastes, and packs, and appeals to all age groups (Ayo and Gidado, 2017). Biscuits have good shelf life at ambient temperature. Being dominantly produced from wheat flour, which lacks essential amino acids such as lysine, tryptophan and threonine. Consequently, the low nutritional value of wheat flour-dependent-snacks is of great concern due to their high consumption by school children who need more protein per unit body weight than adults (Adeleke and Odedeji, 2010). Hence, the need to develop composite flours using local crops like Tigernut tubers for the production of Biscuits, Breads and other Confectioneries.

Tiger nut (*Cyperus esculentus* L.) is an underutilized crop commonly known as Aya in Hausa and Shoho in Tiv languages of northern Nigeria. It has a sweet and nutty taste (Ayo *et al.*, 2016). The tubers are edible and can be eaten raw, dried, roasted, prepared as tiger nut milk or oil, used as a composite in the production of confectioneries, used in making jams, beer and as a flavouring agent in ice cream. According to Abiodun *et al.* (2017) tiger nut is non-allergic and has been reported to be high in dietary fiber which is effective in the prevention and treatment of illnesses such as colon cancer, gastro intestinal disorders, obesity and diabetics, making it suitable for use in making higher fibre biscuits.

The adoption of composite flour intended to replace wheat flour totally or partially in bakery and pastry products has been recommended. This will save money for the country, promote high yielding native plant species, better supply of protein for human nutrition and overall use of domestic agriculture. Again, more individuals are demanding for health-promoting foods with nutritional relevance, hence the drift away from consumption of trans-fat from baking margarine to healthier consumption of plant fat from fruits like avocado. Avocado (*Persea americana*) is known for its pleasing taste and predominance of monounsaturated fatty acids. It is also recognized as a functional food that contains health-promoting phytochemicals such as glutathione and beta-sitosterol (Pooja *et al.*, 2018). Therefore, the objective of this study was to evaluate the sensory characteristics of biscuits produced from wheat- whole tiger nut composite flour, while adopting avocado pear as a fat replacer.

Materials and Methods

Wheat flour, avocado pears (Bacon variety), fresh Tigernut tubers (brown variety) and other baking ingredients were purchased from commercial stockers at Ubani main market, Umuahia.

Production of whole tigernut flour and formulation of composite flour: Fresh tigernut tubers were sorted to remove extraneous substances like stones, pebbles and spoilt tubers before washing with potable tap water. The prepared tubers were dried in a hot air oven (Model no. SX3-4.5-15) at 60°C for 24 hours to a moisture content of 10%. The dried tubers were milled into powder using a commercial hammer mill to obtain whole Tigernut flour (Adedokun *et al.*, 2014). Two batches of composite flours were formulated with the same ratios in each part as follows; 90% Wheat flour: 10% whole Tigernut flour (T10), 80% wheat flour: 20% whole Tigernut flour (T20) and 70% wheat flour: 30% whole Tigernut flour (T30), respectively and then a reference sample 100% wheat flour: 0% whole Tigernut flour (T00).

Avocado pear pulp extraction: Matured and ripened avocado fruits were washed with potable water and the pericarp and seeds were removed. The pulps were then extracted into a thoroughly washed and dried container and mashed in a Sonik blender (Model SFP-2210; 220 V, 50 Hz, 450 W) to obtain a smooth paste. The required sample needed for the production was obtained from the paste obtained (Pooja *et al.*, 2018).

Production of Biscuit samples: Biscuits were produced using the rubbing in method as described by Ahmed and Hussein (2014) with some modifications in the recipe. First, all the

ingredients contained in the recipe as presented in Table 1 were weighed into a stainless mixing bowl. To one part of composite flours (T10, T20 and T30) and the control (T00), the dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for about 3 minutes. Vegetable shortening (margarine) was added and mixed until uniform consistency was achieved. Egg, milk and water were then added and the mixture kneaded. The dough was rolled until a thickness of 1 cm was achieved and cut with a 20 mm diameter biscuit cutter. The shaped batter for biscuit production were placed on greased baking trays, leaving 25 mm spaces in between and baked at 180°C for 10 minutes in the baking oven (Gallenkamp, Model OV 160, England). Following baking, the Biscuits were cooled to ambient temperature and stored in an air-tight transparent plastic container (Plate 1) until baking of all samples were completed. The same process was repeated for the second part of composite flours (AT10, AT20 and AT30). In these samples, the margarine was replaced with avocado paste. After baking and cooling, the samples were subjected to sensory evaluation.

Table 1: Biscuits recipe with different levels of whole tigernut flour and avocado paste substitution.

Ingredient	T00	T10	T20	T30	AT10	AT20	AT30
Wheat flour (g)	500	450	400	350	450	400	350
Whole-tigernut flour (g)	0	50	100	150	50	100	150
Margarine (g)	100	100	100	100	0	0	0
Avocado paste (g)	0	0	0	0	100	100	100
Sugar (g)	250	250	250	250	250	250	250
Baking powder (g)	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Salt (g)	2	2	2	2	2	2	2
Egg (g)	60	60	60	60	60	60	60
Milk (ml)	75	75	75	75	75	75	75
Water (ml)	75	75	75	75	75	75	75

T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30 = 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

Sensory Evaluation

A 25-member semi trained panelists conducted sensory evaluation on the biscuit samples from different combinations. Each sample was placed on white saucer, coded with random 3 digit numbers and presented to the panelists for analysis (Iwe,2010). The biscuits were analyzed for appearance, texture, aroma, taste, mouth-feel and overall acceptability, using 9-point hedonic scale with 1 for disliked extremely and 9 for liked extremely. Panelists were provided with drinking bottled water to rinse their mouths inbetween tasting to avoid carry over taste. Biscuit

samples that scored 5(neither liked nor disliked to extremely liked) and above for overall acceptability were considered acceptable.

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA). Means that were significantly different at $p < 0.05$ were separated using Duncan's Multiple Range Test (DMRT) with Statistical Package for the Social Science(SPSS) Version 21.0.

Results and Discussion

The Biscuit samples are presented in plates 1 to 7.



Plate 1(T00: 0% whole Tigernut flour)



Plate 2 (T10:10% whole Tigernut flour)



Plate 3 (T20: 20% whole Tigernut flour)



Plate 4 (T30: 30% whole Tigernut flour)



Plate 5 (AT10:10%whole Tigernut flour with avocado paste)



Plate 6 (AT20: 20%whole Tigernut flour with avocado paste)

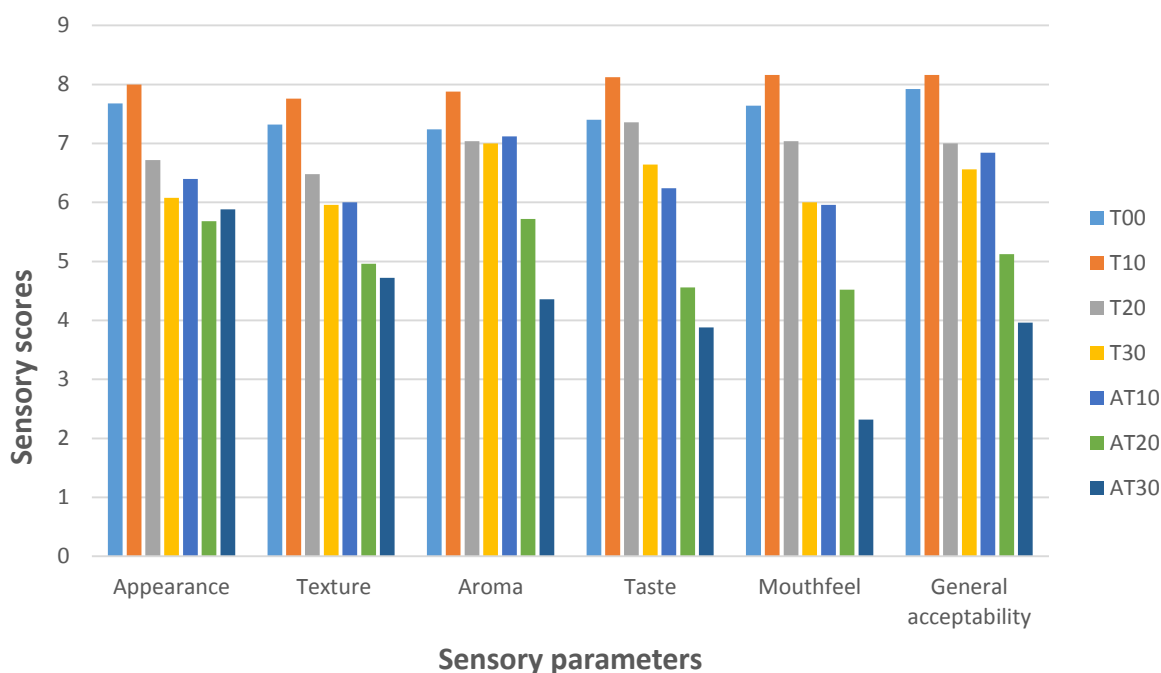


Plate 7(AT30: 30%whole Tigernut flour with avocado paste)

Plates 1 to 7:Physical appearance of seven biscuit samples with different levels of whole tigernut flour and avocado substitution

Sensory characteristics of the Biscuit samples

Sensory scores for each parameter decreased progressively as the level of substitution increased, which is similar to the observation of Adie *et al.* (2020). Biscuit samples baked with margarine were acceptable to the panelists, with sensory scores of not less than 5.0 on the average at the 9-point hedonic scale used for all sensory parameters. In comparison to Biscuits baked with fat substitute (Avocado paste), the texture, taste and mouthfeel of fat substituted Biscuits, especially AT20 (20% whole Tigernut flour with avocado paste) and AT30 (30% whole Tigernut flour with avocado paste) were not acceptable by the panelists while the sensory scores for AT10 were acceptable for all sensory parameters. Generally, in terms of the assessed sensory parameters, T10 (10% whole tigernut flour substitution) was most acceptable, followed by the control sample (T00; 100% wheat flour), then other experimental samples in their order of increasing whole Tigernut flour substitution. Hence, Biscuit samples produced from 90% wheat flour:10% whole tigernut flour (T10) and baked with margarine was rated highest (8.16) among the samples with respect to general acceptability and was liked very much.



Conclusion

This study has demonstrated the potential of indigenous crops such as Tigernut tubers and Avocado fruit in the development of bakery products. Substitution of wheat flour with whole tigernut flour up to 30% and baked with margarine did not adversely affect the sensory properties and overall acceptability of the Biscuit samples. Replacing margarine with Avocado

paste as a fat replacer in the Biscuit samples were acceptable up to 10% whole Tigernut flour substitution. These draw backs can be addressed through product optimization studies. Whole tigernut flour and avocado fruit should be valued as a dietary source to enrich bakery products like biscuits in Nigeria with the intent of developing healthier products.

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Figure 1: Sensory characteristics of biscuits samples influenced by whole tigernut flour and avocado paste inclusions.

Key: T00 = 100% wheat flour: 0% whole tigernut flour. T10 = 90% wheat flour: 10% whole tigernut flour (T10). T20 = 80% wheat flour: 20% whole tigernut flour. T30 = 70% wheat flour: 30% whole tigernut flour. AT = samples containing avocado paste as a fat substitute.

PROXIMATE COMPOSITIONS AND SENSORY PROPERTIES OF CAKES PRODUCED FROM WHEAT FLOUR AND SOURSOP PULP POWDER BLENDS

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Abstract

This work investigated the proximate composition and sensory properties of cakes made from wheat-soursop pulp flour blends. Soursop was washed, peeled and the pulp was extracted. The pulp was oven-dried, milled and sieved to obtain soursop pulp powder. Flour samples were made by partially substituting wheat flour with 10 %, 20 %, and 30 % w/w inclusion levels of soursop powder. The composite flours were mixed with other ingredients and used to produce cakes. The cakes were subjected to sensory evaluation and proximate analysis. The range of values of the cake samples based on proximate analysis were as follows: Protein (5.80% - 10.12%), fat (16.35% - 17.03%), ash (1.30% - 3.91%), crude fiber (3.13% - 10.03%), moisture (15.29% - 18.62%) and carbohydrate (43.62% - 54.80%). Supplementing wheat flour with soursop pulp powder increased the nutritional quality of the cakes with elevated levels of ash, fat, protein and fibre. The outcome of sensory evaluation indicated that the different samples of cake were accepted by the consumers with a predominantly above “7” score using a 9-point hedonic scale on all parameters tested. This work suggests that there are strong potentials for enhancing cake quality via the incorporation of soursop pulp powder.

Key words: Cake, Soursop, Proximate composition, Sensory evaluation, Bakery product.

Introduction

Bakery products or Bakers' confectionery include sweets and baked goods – especially those that are served for the dessert course of a three-course meal. Bakers' confections are sweet foods that feature flour as a main ingredient and are baked. Major categories include cakes, sweet pastries, doughnuts, scones, and cookie [1]. Cake is a special form of sweet food made with ingredients; like wheat flour and variable levels of fat, sugar, egg, milk, baking powder and emulsifiers and other commonly used ingredients such as cocoa powder, nuts, fruits, icing and certain flavourings. It is one of the semi-dry foam foods that have air pockets enclosed in a protein and starch network. It is produced from fluid medium batter using rich characterized formulas that have been expanded by gas resulting from chemical dissolved in the medium. Cake ingredients are excellent sources of carbohydrate that provide the human body, brain and muscles a healthy boost of energy [2]. Wheat is the most important staple food crop for more than one-third of the world's population and contributes more calories to the world's diet than any other cereal crop [3]. Wheat flour is used to prepare bread, produce biscuits, cakes and noodles. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, mineral 2.3% and considerable proportions of vitamins (thiamin and vitamin B) and minerals (zinc, iron).

Wheat is also a good source of trace elements essential for good health [4]. Nonetheless, the allergenic nature of wheat gluten to some consumers, spiraling costs of wheat imports, incomplete nature of the amino acid profile of wheat, amongst others, present a need for composite flour adoption [1].

Soursop is a fruit of *Annona muricata* – a broadleaf, flowering, evergreen tree native to Mexico, Cuba, Central America, the Caribbean, and northern South America, primarily Colombia, Brazil, Peru, Ecuador, Venezuela; as well as in some parts of Africa, Southeast Asia and the Pacific. It is in the same genus as the *chirimoya* and the same family as the *papaya* [5]. The flesh of the fruit consists of an edible, white pulp, some fiber, and a core of indigestible, black seeds. Soursop pulp is most delectable and crucial in nourishing and awakening human health [6]. The demand for this fruit is on the rise due to its benefits in terms of preventing coronary heart disease. The high mineral content in soursop pulp makes it a good dietary source of electrolytes while the high fibre content makes it an ideal food that could be harnessed in the control of cholesterol absorption, regulation of blood glucose levels in normal and diabetic individuals – thereby limiting excessive weight gain and obesity [7].

This study is necessitated in that Soursop (*Annona muricata*) is nutritious, highly perishable and seasonal; and that there are virtually no storage facilities for the produce in Nigeria. In addition, consumers have ever-dynamic tastes and preferences and would yearn for fresh alternatives to the cake options available. Furthermore, the volatility in the exchange rate ensures that the price of wheat keeps rising and this affects the economy and consumers, too. Thus, this research focuses on evaluating the nutrients potential and sensory properties of cakes produced from wheat-toasted soursop pulp blends.

Materials and Methods

The materials (wheat flour, soursop and baking ingredients) used in this research work were purchased at Relief Market, Owerri, Imo State, Nigeria. Selected quantities of the Soursop fruits were taken to the Department of Agricultural Technology, Federal Polytechnic, Nekede, Owerri, Imo State, for identification. Soursop fruits were processed into flour via the method of [8]. Matured and riped soursop fruits (3 kg) were washed under clean running water and peeled carefully. The peeled fruits were sliced into about 5mm thickness, the core and seeds were removed, then the pulp was cut into small pieces and oven dried to a slight toast at 60°C for 48 hours. The dried fruit pulp slices were then milled into flour and finely sieved. The flour obtained was stored air-tight (to exclude moisture and dust particles) at 30°C and held for mixing and production of the cake samples. The wheat and soursop pulp flours were blended in the ratios 90:10, 80:20 and 70:30 while 100% wheat flour was used as the control. An overall flour weight of 250g was adopted for the production of each of the cake samples. The methods described by [1] were adopted for the cake production and sensory evaluation of the cake products. The margarine (250 g) and sugar (125 g) were placed in a bowl and creamed by mixing for 20 min until soft and fluffy. The well-beaten eggs were slowly added while mixing continuously. The sieved flour was lightly mixed in, with baking powder (5 g) and salt (5 g). The resultant batter was poured out into greased baking tins and baked at 160°C for 1 h. The

cakes were de-panned, allowed to cool and thereafter packaged. The sensory evaluation was conducted using a twenty-membered panel of judges drawn from the Federal Polytechnic, Nekede, Owerri community. The procedure of assessing each sample by ingestion, allotting scores based on the evoked responses per sensory parameter (for each sample) and rinsing the mouth with potable water to mask the effect of the previous sample prior to taking the next sample was explained to the panelists before commencement of the sensory evaluation. The quality attributes assessed were appearance (colour), flavour (as aroma and taste), texture (as mouthfeel) and general acceptability. The coded samples were presented to the panelists with potable water to rinse their mouths between determinations, thus masking the sensory attributes of the previous determination. The 9-point hedonic scale, with the following ratings, was used: 1 - Dislike extremely, 2 - Dislike very much, 3 - Dislike moderately, 4 - Dislike slightly, 5 - Neither like nor dislike, 6 - Like slightly, 7 - Like moderately, 8 - Like very much, 9 - Like extremely. The proximate compositions of the cakes were determined according to [9].

Results and Discussion

Table 1 displays the proximate composition of cakes from wheat-soursop pulp flour blends. There were significant ($p < 0.05$) differences amongst the samples across all parameters assessed. The moisture content of wheat-soursop cake samples ranged from 15.29 % to 18.62 % with 100:0 (control) having the highest moisture content value and 70:30 exhibiting the lowest moisture content value. These values correlate with 14.32 – 20.31 % reported by [10] for plain cake enriched with rice rinsed water treated with banana blossom flour. Lower moisture content of foods ensure good keeping quality, and higher moisture content of foods aid spoilage [11]. The ash content of wheat-soursop cake samples ranged from 1.30 % to 3.92 % with 70:30 blend having the highest ash content. These values fall within the range (2.15 % to 3.33 %) reported by [1] for wheat-African pear seed composite flour cake. The ash content of a food material is indicative of the measure of the mineral constituents of the food. The crude fibre content of wheat-soursop cake samples ranged from 3.13 % to 10.03 % with the 100:0 (control) having the lowest crude fiber content and the 70:30 having the highest content of crude fibre. Fibre is associated with lowering the risk of heart disease, stroke, bowel cancer, and a diet rich in fibre can aid digestion and prevent constipation [11]. The fat content of the cake samples ranged from 16.35 % to 17.03 % with 100:0 wheat flour cake having the lowest fat content while the 70:30 Wheat-Soursop composite flour cake had the highest fat content. There were significant differences amongst the samples. The values were higher than 13.21 % to 15.26 % reported by [1] for wheat-African pear seed composite flour cake. The trend may be due to the contribution made by the soursop flour's fat content, with the 70:30 blend having more soursop flour proportions. The protein content of cakes blended with wheat-soursop pulp flour ranged from 5.80 % to 10.12 %, with the 100:0 wheat flour cake (control) having the least protein content of 5.80 % while the 70:30 Wheat-Soursop composite flour cake having the highest protein content (10.12 %). This is because of the sample 70:30 Wheat-Soursop composite flour cake consisted of high proportion of soursop flour unlike the 100:0 wheat flour cake that had only wheat. Thus, it is expected that the amino acid component of soursop flour will complement that of the wheat flour. The carbohydrate content of wheat-soursop

cake samples ranged from 43.62 % to 54.80 % respectively with the 70:30 sample having the least carbohydrate content and the control sample (100:0) had the highest carbohydrate content. The higher proportion of soursop flour in 70:30 might have resulted to a dilution of the carbohydrate content due to increased fibre proportions.

Table 4.2 shows the mean sensory scores of wheat-soursop pulp composite flour cakes. The panelists responses for taste varied from 5.60 to 8.40. The highest appearance rating (8.50) was recorded from the 100:0 wheat flour cake (control) while the lowest appearance rating (6.20) was observed in the 70:30 cake sample. This might be as a result of higher proportion of soursop flour which altered the normal cake colour from the usual golden-brown to a darker shade of brown. The highest value (7.70) of mouthfeel was observed in the 90:10 sample of wheat and soursop pulp flour cake. The 70:30 blend whose value was 5.70 had the lowest mouthfeel based on sensory evaluation as indicated by the panelists. The higher inclusion levels of soursop pulp flour affected the texture of the product as assessed by the palate.

The score for general acceptability ranged from 6.70 to 8.80. It was observed that the values decreased as more soursop pulp flour was added. Sample 70:30 had the lowest value (6.70) for general acceptability while the Control had the highest value (8.80) in terms of general acceptability.

Table 1: Proximate composition of wheat-soursop pulp composite flour cake

Wheat flour: Soursop powder	% Moisture	% Ash	% Fiber	% Fat	% Protein	% Carbohydrate
100:0	18.62 ^a ±0.02	1.30 ^a ±0.03	3.13 ^a ±0.00	16.35 ^a ±0.04	5.80 ^a ±0.02	54.80 ^a ±0.08
90:10	17.51 ^b ±0.02	2.16 ^c ±0.02	4.27 ^c ±0.01	16.42 ^c ±0.01	6.91 ^c ±0.01	52.73 ^b ±0.04
80:20	16.34 ^c ±0.02	2.88 ^b ±0.03	8.90 ^b ±0.03	16.78 ^b ±0.02	8.17 ^b ±0.02	46.92 ^c ±0.08
70:30	15.29 ^d ±0.02	3.91 ^a ±0.03	10.03 ^a ±0.04	17.03 ^a ±0.02	10.12 ^a ±0.02	43.62 ^d ±0.10
LSD	0.03139	0.0426	0.04175	0.0452	0.0289	0.1297

Values are means of duplicate determinations. Means with identical superscripts in the same column are not significantly ($p>0.05$) different. $a>b>c>d$. Sample ratio: Wheat flour: Soursop pulp powder; LSD = Least significant difference

Table 2: Mean sensory scores of wheat-soursop pulp composite flour cake



Wheat flour: Soursop powder	Taste	Aroma	Appearance	Mouthfeel	General acceptability
100:0	8.40 ^a ±0.84	6.80 ^a ±1.75	8.50 ^a ±0.53	7.70 ^a ±0.95	8.80 ^a ±0.42
90:10	7.70 ^a ±1.64	5.90 ^a ±2.08	7.00 ^{ab} ±1.25	6.40 ^a ±3.17	7.30 ^a ±2.87
80:20	5.60 ^b ±1.58	7.10 ^a ±1.73	7.20 ^{ab} ±2.15	7.10 ^a ±1.37	7.40 ^a ±1.17
70:30	7.80 ^a ±1.32	5.10 ^a ±2.88	6.20 ^b ±2.30	5.70 ^a ±1.89	6.70 ^a ±2.36
LSD	1.7840	2.2228	2.1965	2.5883	2.1879

Values are means of duplicate determinations. Means with identical superscripts in the same

column are not significantly ($p > 0.05$) different. $a > b > c > d$. Sample ratio: Wheat flour: Soursop pulp powder; LSD = Least significant difference

Conclusions

The proximate and sensory properties of wheat-soursop pulp blend cakes were successfully investigated in this study. The results from the study revealed that complementing wheat flour with soursop pulp flour in the production of wheat-soursop pulp cakes increased the nutritional quality of the cakes with elevated levels of ash, fat, protein, and fibre. Furthermore, the study has shown the possibility of producing high quality cake from composite flour of wheat and soursop pulp flour with reasonably acceptable sensory appeals.

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FUNCTIONAL AND PROXIMATE COMPOSITION OF WHEAT FLOUR, OKARA AND AFRICAN WALNUT FLOUR FOR COOKIES PRODUCTION

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ABSTRACT

This study investigated the functional and chemical properties of flours obtained from wheat, soybean residue (okara) and African walnut. Commercial wheat flour was obtained from Ogige market in Nsukka. Soybean seeds were cleaned, soaked, boiled, milled and filtered. The fresh soybean residue (okara) obtained was dried and milled into flour. African walnuts were cleaned, boiled, shelled, sliced, dried and milled into flour. These flours were analyzed for their functional and proximate composition. There were significant ($p < 0.05$) differences in bulk density, water absorption capacity and swelling capacity of all the flours. The proximate composition of flours showed that wheat flour (WF) contained protein (13.16%), moisture (7.56%), fat (1.41%), ash (2.48%), fibre (0.47%) and carbohydrate (74.92%). Soybean residue (okara) (SR) contained protein (46.00%), moisture (6.58%), fat (5.99%), ash (2.58%), fibre (15.25%) and carbohydrate (23.60%). African walnut flour (AFW) contained protein (29.75%), moisture (4.16%), fat (14.79%), ash (2.09%), fibre (3.92%) and carbohydrate (45.29%). The caloric values of wheat flour, soybean residue and African walnuts flour were 346.28 kcal/100g, 326.41 kcal/100g and 421.95 kcal/100g, respectively.

Key words: Wheat, Okara, African walnut, Functional properties, Proximate Composition

INTRODUCTION

Flour is a basic ingredient and it is supposed to be of optimum quality appropriate for a certain product. Wheat flour is the main ingredient in conventional bakery products such as bread, cakes, and cookies amongst others. The major factor for the suitability of wheat varieties for making different types of bakery products is the ability to form gluten network. However, gluten network has greater importance in product such as bread, unlike cakes and cookies. Currently, the flour-based confectionery industry is facing different challenges in reducing calories and increasing nutritive values in order to produce healthier products. In addition to wheat flour, these products include sugar and fat, which contribute to high energy but are mostly poor in nutritional terms. Due to frequency of consumption, they can impair a balanced diet, especially when it comes to children and young people. Therefore, the greatest influence on improving the functionality and nutritive value of flour-based confectionery just involves the replacement of flour in recipes with other kinds of flours, such as whole meal wheat flour

and flours obtained from other cereals and non-cereals with evident nutritive and non-nutritive values like oat, barley, rice, soy, buckwheat, flaxseed etc. In addition, protein fortification of cookies is of current interest and they can be prepared from composite flours, such as wheat flour fortified with soy, cottonseed, peanut, corn germ flour, mustard flour or walnuts flour. Soybean residue (okara) contains mostly dietary fibre (42.4–58.1%), 25% protein, 10-15% oil, but little starch or simple carbohydrates. It is a suitable dietary additive in biscuits and snacks because it reduces calorie intake and increases dietary fibre. According to Udediet *et al.* (2013), African walnut is rich in protein, fat, carbohydrate but lower fibre and ash content. The nuts have also been found to be very good sources of vitamins A, B₁, B₂, B₆, E, folate, sodium, potassium, manganese, copper, chloride, iron and ascorbic acid. Furthermore, they contain omega-3 essential fatty acids and have antihyperglycaemic effect (Onwuliet *et al.*, 2014). The use of these underutilized raw materials for partial replacement of wheat flour in cookies will likely improve the functional properties and nutrient density of the product.

MATERIALS AND METHODS

Procurement of Raw Materials

Wheat flour and soybeans were purchased from Ogige Market in Nsukka Local Government Area, Enugu State; while African walnuts were sourced from Eke market, Ekwulobia, Anambra State.

Processing of Raw Materials into Flour

Okara was produced from soybean seeds. The seeds were manually sorted to remove bad seeds and foreign bodies. The seeds were washed and soaked in potable water at seed to water ratio of 2:1 for 12 h to loosen the seed coat. The seeds were thereafter dehulled, wet milled, boiled for 30 min and filtered to harvest the residue. The residue (fresh okara) was then dried and pulverized into flour. The fresh African walnut was also processed into flour. The seeds were washed thoroughly to remove sand, boiled for 30 min, shelled and cut into slices to facilitate drying. The slices were then drained and oven dried at 70°C for 24 h. The dried slices were milled into flour and sieved using 60 mm size mesh to obtain flour of uniform size. The flour samples were sealed in well labeled airtight containers and stored at room temperature (28 °C±2 °C) prior to analysis.

Determination of Functional Properties of the Flour Samples

The Bulk Density of the flour samples was determined by the method of Okaka and Potter (1979).

Water Absorption Capacity (WAC) was determined using the method of Lin *et al.* (1974) on 1g sample Swelling Capacity was determined by the method described by Ukpabi and Ndimele (1990) on 10g sample.

Determination of Proximate Composition

Moisture, crude protein, fat, fibre and ash contents were determined using the method of AOAC (2010). Carbohydrate was determined by difference.

Statistical Analysis

The experiment was designed using Completely Randomized Design. All data generated was subjected to one way analysis of variance and Duncan's Multiple Range Test was used to separate the means at 5% level of significance.

RESULTS AND DISCUSSION

The results of the functional properties of the flours are shown in Table 1. The bulk density values ranged from 0.66 to 0.81g/cm³ and were all significantly ($p < 0.05$) different. Wheat flour had the highest value and soybean residue had the lowest value. This implies that soybean residue would require more packaging space since the lesser the bulk density, the more packaging space is required. There were significant ($p < 0.05$) differences in the bulk density of all the samples. Low bulk density of flours has been reported to be useful for food formulation with less fear of retrogradation. The water absorption capacity (WAC) is the ability of a product to associate with water under limiting conditions (Singh, 2001). The water absorption capacity of flour samples ranged from 99.60 to 298.16%. Soybean residue had the highest value while wheat flour had the lowest value. The high water absorption capacity of soybean residue could be attributed to its higher fibre content. According to Nasiret *al.* (2008), the differences in water absorption capacity is mainly caused by the greater number of hydroxyl group which exist in the fibre structure and allow more water interaction through hydrogen bonding. Flours with high WAC have more hydrophilic constituents, such as polysaccharides. Water absorption capacity enables bakers to add more water to dough and so improve handling characteristics and maintain freshness of the baked products. There were significant ($p < 0.05$) differences in water absorption capacity values of the flours.

The results obtained for swelling capacity of the flour samples ranged from 15.39 to 91.66% with the highest value observed in soybean residue. There were significant ($p < 0.05$) differences in the swelling capacity of all the samples. Swelling power of granules is an indication of the extent of associative forces within granule. Swelling power is also a function of the ratio of amylose to amylopectin; and amylopectin is primarily responsible for granule swelling. The higher amylopectin contents in flour the higher the swelling power of flour. Swelling capacity of flours also depends on particle size, variety and method of processing.

Table 1: Selected functional properties of unblended flour from wheat, soybean residue and African walnut flour

Sample	Bulk density (g/cm ³)	Water absorption capacity (%)	Swelling capacity (%)
Wheat flour	0.81 ^a ±0.00	99.60 ^c ±0.14	25.20 ^b ±0.28
Soybean residue (Okara)	0.66 ^c ±0.00	298.16 ^a ±0.07	91.66 ^a ±0.01
African walnut flour	0.71 ^b ±0.00	143.15 ^b ±0.07	15.39 ^c ±0.01

Values are means ±S.D of duplicate determinations. Values in the same column with different superscripts were significantly ($p < 0.05$) different.

WF=Wheat flour, SR=Soybean residue (okara), AFW=African walnut

The proximate and caloric values of flours are shown in Table 2. The protein content of the flour samples ranged from 13.16 to 46.00% and there were significant ($p < 0.05$) differences in all the measured parameters. The highest protein value was observed in soybean residue (46.00%), suggesting a potential source of low-cost vegetable protein for human consumption. The result showed that the protein content of African walnut flour was 29.75% which can be compared with the value (28.00%) reported by Udediet *al.* (2013) for comparative studies on walnut. Wheat flour had the lowest protein value (13.16%) which showed that wheat contributes low protein to diet. It contains a special protein known as gluten which contributes to dough elasticity and strength. Flour proteins of soybean residue and African walnut do not form gluten. Most cookies can be made from flour which has gluten that is weak and extensible. These processed flours from soybean seeds and African walnuts, may sometimes be useful to “dilute” wheat flour in cookies production. This can help to make the dough less tough and easier to sheet. In addition, soybean residue and African walnut flour can be major sources of high quality protein for dietary cookies.

The moisture content of the flour samples ranged from 4.16 to 7.56%. These values are below the minimum limit of moisture content for flour. The values are therefore low enough for adequate shelf life stability if packaged in moisture-proof containers. The ash contents of the flour samples ranged from 2.09 to 2.58% which shows the presence of some minerals in the flour samples. Soybean residue had the highest ash content (2.58%), followed by African walnut flour (2.48%) while wheat flour had the least value (2.09%). This could be due to higher mineral content in soybean residue and African walnut flour. The crude fibre content of flours ranged from 0.47 to 15.25%. There were significant ($p < 0.05$) differences in the flour samples. Soybean residue had the highest value of crude fibre 15.25% which is in line with the report by Liet *al.* (2012), who stated that soybean residue had crude fibre range of 14.5% to 18.6%. Wheat flour had the least crude fibre content which could be due to its refined nature. Fibre aids in lowering blood cholesterol level and slows down the process of absorption of glucose, thereby helping to keep blood glucose level in control. It also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body, increases satiety

and hence impacts some degree of weight management (Miketinaset *al.*, 2019). It is worthy of note in this study for its health significance and therefore means that the addition of soybean residue in flour is of nutritional importance. There were significant ($p < 0.05$) differences in fat content of the flour samples. African walnut flour had the highest fat content (14.79%). The oil was reported to be an excellent source of omega-3 essential fatty acids; a special type of protective fat which the body cannot manufacture.

The carbohydrate content of flour samples ranged from 23.60 to 74.92%. The carbohydrate content of wheat flour (74.92%) was higher than that of soybean residue and African walnut flour. There were significant ($p < 0.05$) differences in the carbohydrate content of the flour samples. The high carbohydrate value of wheat flour can be attributed to the carbohydrate value of the raw material which was not so much affected by processing. The calorific values of flour samples ranged from 326.41 to 421.95 kcal/100g. African walnut flour had the highest energy value while soybean residue had the least value. Soybean residue is rich in fibre and high fibre foods tend to be low in energy. The high fat content of African walnut flour could have contributed to its high energy value (Udediet *al.*, 2013).

Table 2: Proximate and calorific values of unblended flour from wheat, soybean residue and African walnut flour

Sample code	Protein (%)	Moisture (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Calorific values (kcal/100g)
WF	13.16 ^a ±0.01	7.56 ^a ±0.01	1.41 ^c ±0.07	2.48 ^a ±0.00	0.47 ^c ±0.04	74.92 ^a ±0.01	346.28 ^b ±0.02
SR	46.00 ^a ±0.03	6.58 ^b ±0.00	5.99 ^b ±0.01	2.58 ^a ±0.00	15.25 ^a ±0.00	23.60 ^c ±0.07	326.41 ^c ±0.01
AFW	29.75 ^b ±0.00	4.16 ^c ±0.04	14.79 ^b ±0.04	2.09 ^c ±0.00	3.92 ^b ±0.00	45.29 ^b ±0.00	421.95 ^a ±0.07

Values are means ±S.D of duplicate determinations. Values in the same column with different superscripts were significantly ($p < 0.05$) different. WF=Wheat flour, SR=Soybean residue (okara), AFW=African walnut

CONCLUSION

The results of functional and proximate properties observed in this study have shown that soybean residue (okara) and African walnuts flours can contribute to improved quality attributes of food products such as cookies; and also have the potentials to serve as vehicles for nutrient delivery in snacks ordinarily produced with wheat flour.

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**PROXIMATE COMPOSITION AND PHYSICAL PROPERTIES OF BISCUIT
PRODUCED FROM COMPOSITE FLOUR OF WHEAT, ACHA AND DATE
FRUIT PALM FLOUR BLENDS**

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Abstract

The objective of the study is to determine the effect of acha and date flour addition on the proximate composition and physical properties of wheat-based biscuit. The *achag* grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes. The washed and de-stoned grains were dried and milled into flour; the date fruit palm were sorted, cleaned, washed and were spread on a clean stainless tray under direct sun light then milled into flour. The flour were proportioned into four different samples (D₀) = 100 % wheat, 0 % acha and 0 % date fruit palm, (D₁) = 60 % wheat, 30 % acha and 20 % date fruit palm, (D₂) = 50 % wheat, 35 % acha and 15 % date fruit palm and (D₃) = 40 % wheat, 40 % acha and 20 % date fruit palm for the production of biscuits. Proximate composition and physical properties of the biscuits were determined. The moisture, crude protein, crude fat, ash and crude fibre increase from 13.43 to 14.09 %, 11.04 to 14.99 %, 8.21 to 10.05 %, 2.52 to 3.91 % and 2.82 to 3.64 % respectively; while the carbohydrate content of the biscuits decreased from 61.98 to 53.32 % with increase in the addition of the acha and date fruits palm flour. The physical properties of the composite biscuits such as the weight, diameter, thickness and spread ratio ranged from 15.61 to 16.71 g, 61.88 to 63.20 mm, 10.21 to 11.99 mm and 5.28 to 6.06 respectively. The result obtained from this study indicate that acha and date fruit palm are good source of composites flours and can be used to substitute wheat flour in biscuits production to reduce the importation of wheat flour into Nigeria.

Keywords: biscuits, date fruit palm, moisture, thickness, spread ratio.

Introduction

Biscuits are the most popular bakery products worldwide. Biscuits are ready to eat, cheap and conventional food. Different types of biscuits contain high contents of fat, sugar and calories, but they are low in fibre, vitamins, and minerals. Thus, they do not correspond to the rules of a healthy diet. Biscuits have a longer shelf life, good taste and are accepted as snacks in all age groups. Therefore, biscuits are considered as a good product for fortification and nutritional improvement. The main ingredient generally used for biscuits is high quality wheat flour with other ingredients, such as butter, margarine, sugar, eggs, milk and some plant species; Production of biscuits is considered as a very important part of the food industry, because the crackers have a high nutritional value, especially when raw materials which are prepared from are rich in fats, carbohydrates and proteins (Suliman *et al.*, 2008).

Acha is a good source of calories and other nutrients but its protein is of lower nutritional quality than bambara and pea nut proteins as its protein is deficient in essential amino acids such as lysine and Threonine (Ogbannaya and Aminat, 2008). Fortification of acha flour with inexpensive staples, such as cereals and pulses, helps in improving the nutritional quality of acha products (Ogbannaya and Aminat, 2008).

Dates are a very good source of numerous nutritive components, viz., sugars, proteins, fats, dietary fibers, minerals (Punia, 2016). It is preferable to consume dates regularly, because of its beneficial properties in increasing sexual stamina, reducing sterility, decreasing fatigue and sluggishness in anemic patients (Punia, 2016).

As an innovative mixture, composite flour has attracted much attention in research as well as food product development (Emmanuel *et al.*, 2019). Most composite flours have better nutritional value concerning elements of minerals, vitamins, fibres and proteins than flour milled from any specific cereal alone. In the developing countries of Africa and other parts in the world, the use of composite flours has benefits in saving of foreign currency and promotion of high yielding indigenous plant species. The use of composite flour would promote overall domestic agricultural ventures; It is considered economically advantageous to reduce or even eliminate importation of wheat while meeting demand for bakery products using locally grown raw materials; Efforts have been made in many countries to produce baked products by conventional methods from wheat flour to which other flours are added. This research was carried out to determine the potential of wheat, acha and date fruit palm flour blends in the production of biscuits.

Materials and Methods

Source of Materials

Raw materials including wheat flour, butter, eggs, salt, sugar, baking powder and vanilla flavour were purchased from KauraNamoda market. Acha and Date palm fruit were purchased from Gusau market, Zamfara State and were taken to the department of Food Technology, Federal Polytechnic KauraNamoda for further processing. All laboratory materials and reagents used were obtained from Food Chemistry Laboratory of the Department of Food Technology and were of analytical grade.

Sample Preparations

Preparation of *Acha* Flour

Acha flour was produced using the method of Ayo *et al.* (2007). *Acha* grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes. The washed and de-stoned grains were dried in a cabinet drier at 60 °C to a moisture content of about 12 %. The dried grains were milled using attrition milling machine and the flour sieved to pass through a 0.5 mmsieve (Endecotts Ltd London, England). The *acha* flour was packaged in air tight containers for used.

Production of Date Fruits Flour

Date fruit flour was produced using the method described by Punia (2016) with modification. Date fruits (2000 g) were sorted, cleaned, washed. The Date fruits were spread on a clean stainless tray under direct sun light. The date fruits were milled into flour using hammer mill (Brem-

mer, Germany Model AR 73442). The flour was sieved with the aid of a 0.5 mm sieve (Endecotts Ltd, London, England) to obtain a uniform particle size of 0.5 mm flour which was packaged in polyethylene bag and stored at 4-6 °C till needed.

Determination of Proximate Composition and Physical Properties of the Biscuits

The proximate composition of the biscuits from wheat, acha and date fruit palm were determined according to the methods described by AOAC (2012) and Carbohydrate content was determined by difference according to the method described by Onwuka (2018). The physical properties (weight, diameter, thickness and spread ratio) of the biscuits were determined by the methods described by Onwuka (2018).

Statistical Analysis

Data generated from the respective analyses were compiled appropriately and subjected to Analysis of Variance. Mean separation for sensory results was done using the Fischer's least significance difference test. All other data had the means separated using the Duncan Multiple Range test (GENSTAT Statistical package, version 17.0).

Results and Discussion

Table 1: Proximate Composition of Biscuits

Sample	Moisture (%)	Protein (%)	Crude Fat (%)	Ash (%)	Crude Fiber (%)	Carbohydrate (%)
D ₀	13.43 ^a ±0.03	11.04 ^a ±0.03	8.21 ^a ±0.02	2.52 ^a ±0.02	2.82 ^a ±0.10	61.98 ^a ±0.16
D ₁	13.75 ^a ±0.03	13.64 ^b ±0.04	9.22 ^b ±0.02	3.44 ^b ±0.04	3.30 ^b ±0.03	56.65 ^b ±0.09
D ₂	13.95 ^{ab} ±0.05	14.72 ^c ±0.02	9.89 ^c ±0.02	3.77 ^c ±0.01	3.55 ^c ±0.01	54.12 ^c ±0.06
D ₃	14.09 ^{ab} ±0.03	14.99 ^c ±0.09	10.05 ^c ±0.06	3.91 ^c ±0.03	3.64 ^c ±0.04	53.32 ^c ±0.20
LSD	0.22	0.37	0.18	0.11	0.15	0.22

Values are means ± standard deviations of triplicate determinations. Means in same column with same superscript are not significantly ($p > 0.05$) different

Key:

D₀ = 100 % wheat, 00 % acha and 00 % date fruit palm

D₁ = 60 % wheat, 30 % acha and 20 % date fruit palm

D₂ = 50 % wheat, 35 % acha and 15 % date fruit palm

D₃ = 40 % wheat, 40 % acha and 20 % date fruit palm

Table 2: Physical Properties of the Biscuits

Sample	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio
D ₀	15.61 ^a ±0.01	63.20 ^a ±0.01	11.99 ^a ±0.01	5.28 ^a ±0.01
D ₁	16.02 ^b ±0.01	62.09 ^b ±0.01	10.50 ^b ±0.01	5.91 ^b ±0.00
D ₂	16.30 ^c ±0.01	61.98 ^c ±0.02	10.29 ^c ±0.01	6.02 ^{b,c} ±0.00
D ₃	16.71 ^d ±0.02	61.88 ^d ±0.04	10.21 ^{c,d} ±0.01	6.06 ^c ±0.01
LSD	0.04	0.05	0.18	0.12

Values are means ± standard deviations of triplicate determinations. Means in same column with same superscript are not significantly ($p>0.05$) different

Key:

D₀= 100 % wheat, 00 % acha and 00 % date fruit palm

D₁= 60 % wheat, 30 % acha and 20 % date fruit palm

D₂= 50 % wheat, 35 % acha and 15 % date fruit palm

D₃= 40 % wheat, 40 % acha and 20 % date fruit palm

Proximate Composition of the Biscuits

Proximate composition provides information about the major nutrient contents of feeds and feedstuffs. The idea is for the required major nutrients (protein, fat and carbohydrate) to be fixed and replacements of ingredients can be done in the formulation (Jobling, 2001).

Moisture content is an indicator of shelf life stability; increase in moisture content enhances microbial contamination and chemical reactions that could lead to reduction in the food quality and stability. The moisture content is below 14% recommended for long period of storage, hence a good potential during storage (Ogunlakin *et al.*, 2012).

The protein content of the biscuits ranges from 11.04 to 14.99 %, the increase in protein content of could be due to the protein content in the acha and ingredients used. The increase in protein content are within the range reported by Suresh *et al.*(2015).

Lowest fat content was recorded in the wheat four control biscuits (D₀) and the highest was in composite biscuits (D₂). The presence of high fat content in the biscuits means high calorific value and also serves as a lubricating agent that improves the quality of the product, in terms of flavour and texture. The ash content of a food material could be used as an index of mineral constituents of the food because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent (Sanniet *al.*, 2008). The level of the ash contents of both controls and composite biscuits suggest that the product would provide more minerals to consumers.

The high fibre contents of the biscuits are good enough for the body because their presence in food products are essential owing to their ability to facilitate bowel movement (peristalsis), recently the importance of consuming dietary fibre has increased owing to its relation with the reduction of blood cholesterol levels and incidence of colon cancer.

There was a significant reduction in the carbohydrate content of the biscuits. This could be attributed to the high protein and fat contents of biscuits as the result of the biscuits recipes used.

Physical Properties of the Biscuits

The weight of the biscuits samples increased with an increase in *acha* and date palm fruits flour substitution. The significant difference between the various weight of the biscuits samples could be due to the increase in the fibre content. The result was not in accordance with Ayo et al. (2007) who reported a significant reduction weight of biscuits produced from wheat supplemented with soybean.

There was a significant decrease between the composite biscuits and the control sample values obtained for the biscuits diameter supplemented with *acha* and date fruit palm flour. As the proportion of *acha* flour increased in the formulation a decreased in the average biscuits diameter was observed. The thickness of the biscuits was found to be significantly influenced both by blend proportion and baking temperature ($p > 0.05$). However a decreased in the average thickness of the biscuits was observed as the proportion of *acha* flour was increased in the formulation with 20 % date fruit palm flour. The control (100% wheat) biscuits showed a larger thickness (11.99mm) as compared to the other blend proportion. Spread factor is the ratio that depends on the values of the thickness and diameter of the biscuits and it is one of the main factors in achieving a good quality product was also studied. As the result indicated, the average spread ratio of the biscuits was found significantly influenced by blend proportion ($p < 0.05$). The average spread ratio of the biscuits showed significantly decreased as the proportion of *acha* flour was increased in the formulation at constant percentage of date fruit palm flour. The 100 % biscuits had higher spread ratio compared to composite biscuits.

Conclusion

An increase was observed in the protein, fat, fibre and ash with increase in the substitution of wheat flour while there was a decrease in carbohydrate. The physical properties of biscuits such as weight and spread ratio increased as a result of the increase level of *acha* and date fruit palm flour substitution, while there was a decrease in the Diameter and Thickness.

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WHEAT PRODUCTION AND FOOD SECURITY: GLOBAL STATISTICS AND THE NIGERIAN SITUATION – A REVIEW

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Abstract

This paper aims to review the current world wheat production and how it affects Nigerian and global food security. Wheat contains higher protein compared with maize and rice and has been reported as the leader among sources of cereal protein. Wheat has a low glycaemic index, therefore, it is a healthy form of starch which is good for the body. Wheat is rich in Vitamin E and the B-group vitamins (mostly niacin) except Vitamin C. The endosperm cell walls contain the minerals. Wheat is the most commonly used cereal grain in the globe and it happens to be the most acceptable by most ethnicity, tribe, race and religion around the continents of the world. It is the most suitable in confectioneries due to its gluten content as seen in bread making. The demand for wheat far exceeds the supply which poses a threat to global food security which has been managed by the use of composite flours, however, the demand for wheat still exceeds supply. Wheat is an important global food security commodity. Global wheat prices are on the rise as a result of the Russia and Ukraine war, both countries account for about 30 % of global world trade of wheat. From the figures in this review, global wheat production seems to still be at an acceptable level, Nigeria on the other hand, is making conscious effort to increase wheat production so as to address food security issues.

Keywords: Wheat, Production, Uses, Challenges, Prospects

Introduction

Wheat is an important global food security commodity (Karatayev *et al.*, 2022). Unfortunately, climate change poses a threat to global food security as stated by Jiang *et al.* (2022). Generally, cereals supply fifty percent of human energy needs. Enghiad *et al.* (2017) referred to wheat as a key global commodity and a staple in household diets. Wheat is a staple food which is used by all nations and cultures. Wheat is a cereal which is consumed globally and has formed an important part of the human diet especially in developing countries. Wheat has been grown for more than eleven thousand years and one of the most important domesticated food crops in the world, the wild species first grew in the Middle East. Wheat has its origin in Southwest Asia where it is commonly used in the production of foods such as pasta, noodles and more commonly bread and chapatti. In India, more than 90 % of wheat is consumed as chapatti. In India and some parts of Middle East, Chapatti is the commonest staple food from wheat. According to United States Department of Agriculture, 725 million tonnes of wheat was produced in 2015 globally. It has been reported that the annual local production of wheat in Nigeria is ten thousand metric tonnes whereas its demand is as high as six million metric

tonnes annually. The United States Department of Agriculture data shows that Nigeria has annual demand of between 4.5 and 5.0 million tonnes of wheat but produces only about 60,000 metric tonnes. This implies that ninety percent of wheat locally consumed is imported. This has increased dependence on importation of wheat from other countries. Most plant-based foods in the globe contain cereal as the major ingredient. This makes cereals the most important among the food crops. The most commonly used cereal grains include wheat, rice and maize. Wheat contains more proteins than maize and rice. Due to the cost of wheat, most food processors are now diverting to maize and rice. Cereal flours are used most times as ingredients in extruded foods. Román *et al.*, (2018) reported that wheat and rice are the most commonly used cereal flours in developed countries as gluten and non-gluten flours respectively. Wheat has been acknowledged as the most important cereal crop in the globe and shortage of wheat will lead to a global food crisis, therefore, there is a need to review the current world wheat production and how it affects Nigerian and global food security.

Uses of wheat

Wheat is mostly used in the form of flour. The protein content and grain composition of wheat determines the use of the wheat. The quality of product is determined by the quality of flour, a very good example is seen in bread making. Due to the gluten content of wheat, it is the commonest used cereal in bread production. Bread is the major product produced from wheat flour and it is the most consumed baked product worldwide. The major difference between wheat flour and flours from other cereals is the ability of dough formation in wheat flour. There are two types of wheat with respect to their protein (gluten) content: hard wheat and soft wheat. Hard wheat flour has high protein content while soft wheat flour contains lower quantity of protein. Due to the high protein content of hard wheat flour, it is used in production of bread and fine cakes while soft wheat flour is used in the production of breakfast products, cookies and crackers. Wheat flour is used mainly in the production of snacks such as pies, biscuits, cookies. It is also used in the production of pizza. Durum wheat is the most cultivated common wheat; it is used for pasta products such as macaroni and spaghetti. Starch may be derived from wheat. Starch is commonly used in industries (food and non-food) and in the home. Due to the pasting property, it is used in products such as custards, gravies and soups. The starch obtained from wheat may be used in confectionery and brewing after being converted to syrup. Due to the bonding properties of the starch, it may be used as adhesive in cardboard boxes. The starch may also be modified and used in paper and fabrics sizing. Globally, there is high demand of some processed foods like bread and noodles. The use of wheat has been streamlined recently, mainly to obtain a wide range of grain quality for diverse purposes.

World wheat production

Wheat is a cereal which is consumed globally and has formed an important part of the human diet especially in developing countries. China ranked number one in wheat producing countries (World Population Review, 2022). In the near future, the Russia-Ukraine war may likely

affect world wheat production which will in turn likely affect global food security especially in African countries such as Nigeria. As at 2018, both Russia and Ukraine were among the top wheat suppliers in Nigeria, with Russia topping the list (Dambazau *et al.*, 2021). Ukraine is a major wheat exporter. United States Department of Agriculture/Foreign Agricultural Service recently reported that the Russian invasion of Ukraine has significantly affected global grain markets. It was also reported that as a result of the war, Ukraine has almost ceased export of wheat and is struggling to resume transportation by rail instead of by sea, however, Russia has resumed wheat exports with steady prices. Presently, despite the crisis, global wheat production seems to be increasing (Figure 1) with a good value of 778.6 million metric tonnes. It is possible that the value here was calculated before the crisis hence, the high value which implies that the negative effect of shortage is yet to be felt and will be severe if urgent steps are not taken to increase and sustain global production.

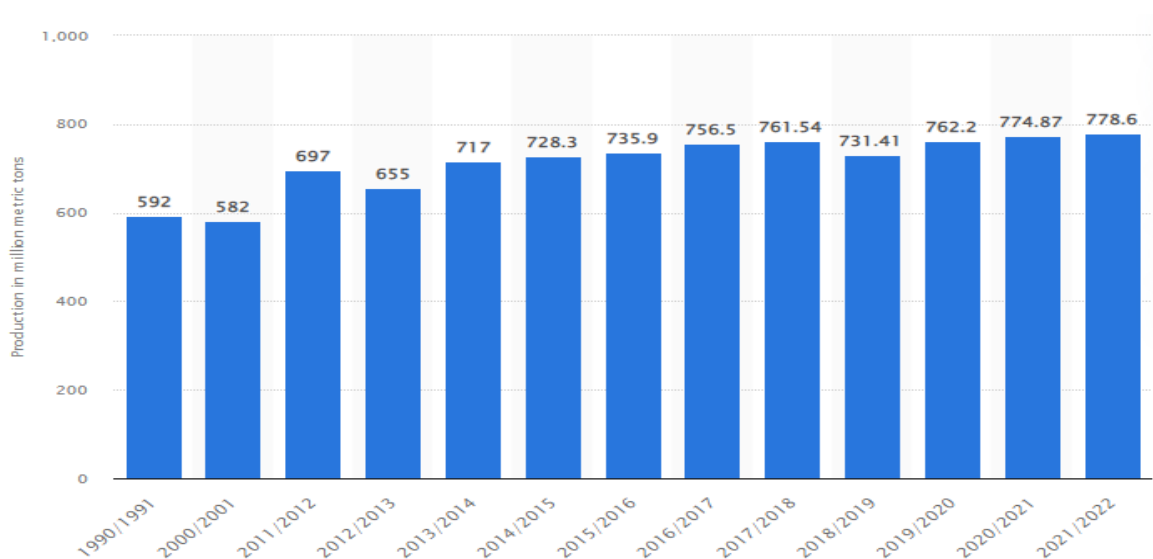


Figure 1: Global wheat production from 2011/2012 to 2021/2022 (in million metric tonnes)

Source: (Statista, 2022)

Wheat production in Nigeria

The importance of wheat in Nigeria cannot be overemphasized. Many foods (noodles, bread and spaghetti) and snacks (cakes, biscuits and cookies), including local foods (*danwake*, *fura* and *tuwo*) we eat in Nigeria are made from wheat. Wheat bran is used in the production of animal feed. The states in Northern Nigeria which support wheat production include Kano, Yobe, Bauchi, Zamfara, Kaduna, Kebbi, Gombe, Sokoto, Katsina, Jigawa, Adamawa and Borno. Wheat production in Nigeria has been low (Table 1) over the years (Dambazau *et al.*, 2021). Dambazau *et al.* (2021) in a review concluded that for Nigeria to attain self-sufficiency in wheat production, implementation of long term plans in a phase wise manner is necessary. During the fourth Annual Nigerian Food Processors and Nutrition Leadership Forum in March 2022, the Chairman of the forum, Alhaji Aliko Dangote expressed concerns that there will be food

shortage, especially wheat in June 2022 as a result of the Russia-Ukraine war. He added that Russia and Ukraine produce 30 % and 26 % of the world's urea and potash respectively including phosphate so as a result, there will be a scarcity of fertilizer which will affect crop yield. Alhaji Aliko Dangote's forecast on shortage of wheat corroborates the earlier statement of Mr. Boye Olusanya, the Chief Executive Officer of Flour Mills of Nigeria who stated that the Russia and Ukraine war will adversely affect world wheat production hence the crisis will affect Nigeria and other African countries through food shortage especially wheat (Alabi, 2022).

Table 1: Wheat Production in Nigeria (2000 – 2020)

S/N	Year	QUANTITY (1000 metric tonnes)
1	2001	51
2	2002	54
3	2003	58
4	2004	62
5	2005	66
6	2006	71
7	2007	44
8	2008	53
9	2009	80
10	2010	110
11	2011	165
12	2012	100
13	2013	80
14	2014	91.3
15	2015	60
16	2016	60
17	2017	67
18	2018	60
19	2019	60
20	2020	60

Source: (Dambazau *et al.*, 2021)

According to one of the Nigerian Dailies, the Ministry of Agriculture recorded 60,000 metric tonnes of wheat produced in Nigeria in 2016 while the National Bureau of Statistics reported 36,943 metric tonnes of wheat produced in Nigeria in 2021 (Okojie, 2022). The identified states which contributed to the 36,943 metric tonnes include Kano, Jigawa, Kebbi, Bauchi, Kaduna, Gombe, Yobe, Katsina, Plateau, Sokoto, Zamfara, Borno and Adamawa. Kano contributed the highest at 6,512.8MT; then Jigawa, 5,854.8MT; and Kebbi, 4,422MT (Nnodim, 2022). Okojie (2022) stated that wheat production in Nigeria faced a decline of over 38 % in five years despite the funding by the federal government to boost output and has attributed this decline to farmers' preference for cultivation of rice, insecurity, corruption and lack of close supervision. A former Executive Director at Lake Chad Research Institute, Olusanya Olabanji has attributed this decline to insecurity owing to the fact that Borno state used

to be the largest producer of wheat in Nigeria but now ranked twelfth among the major producing states (Okojie, 2022). As a result, wheat import is accelerated in Nigeria despite the dollar shortages. Nigeria is presently facing unprecedented high cost of food items generally (Dambazau *et al.*, 2021). The United States Department of Agriculture suggested that the Nigerian government needs to ensure that millers buy local wheat at a fixed price (\$400) per tonnes but stated that the members of the Wheat Farmers Association of Nigeria (WFAN) prefer selling to Non-governmental agencies and Sahel countries like Niger, Chad, Mali and Burkina Faso due to the more attractive markets. However, experts have said that with the Central Bank of Nigeria new initiative programmes to boost wheat production and flour millers commitment, wheat production target of 400,000 metric tonnes will be achieved in 2023 (Okojie, 2022).

Conclusion

World wheat production is a very important topic as it relates to food security. Wheat is a grain used worldwide for both food and non-food uses and it is globally accepted. Its production needs to be sustained so as to ensure that food security is adequately kept in check. From the above findings, Nigeria is making conscious effort to increase wheat production so as to address food security issues. From the figures above, global productions seems to still be acceptable.

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FUNCTIONAL AND BREAD MAKING PROPERTIES OF NIGERIAN BAKERY FLOUR SUPPLEMENTED WITH ORANGE-FLESHED SWEET POTATO AND AFRICAN BREADFRUIT

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Abstract

Flour Mills in Nigeria are mandated by law to include 10 – 20% cassava in all commercial bakery flours. Flour used in this study had 20% cassava flour and was complemented with orange-fleshed sweet potato (OFSP) and African breadfruit (ABF) to improve bread quality. This will also add value to these food crops industrially. Both complement for improved protein, fibre and ash content; and complete essential amino acid contents at levels limiting in most Nigerian meals. Sprouted ABF seeds and OFSP roots were processed into flours which were blended (%) with commercial flour at 0 and 0, 20 and 5, 15 and 10, 10 and 15, 5 and 20; and 12.5 and 12.5 % respectively. Breads were baked, and the flours and breads analysed for quality. OFSP and ABF enhanced functional properties of flours. ABF improved crude protein and fat content but both ABF and OFSP improved fibre and ash contents of breads. Protein content was 11.32% in control bread but 11.32% to 12.57% in experimental breads. Experimental breads had comparable physical and sensory properties with the control, and were all acceptable; SF with equal OFSP and ABF was the most acceptable experimental bread.

Key words: Orange-fleshed sweet potato, African breadfruit, Fortification, Flour functionality, Bread quality

Introduction

In Nigeria, bread has become the second most widely consumed non indigenous food product after rice in most homes, restaurants and hotels (Olapade and Oluwole, 2013). Bread is eaten as snack and staple. It is not a balanced diet as it is naturally low in protein, particularly the essential amino acids tryptophan and lysine, and most micronutrients. Wheat is the base ingredient for bread production but most wheat consumed in Nigeria is imported at a high cost. Its production is not favourable in Nigeria. As a result, Nigerian government has promulgated compulsory inclusion of 10 – 20% of cassava flour in all Nigerian bakery flours (Shittu et al., 2007). Commercial flour used in this study had 20% cassava flour Such flour would be of poor

functional property, and would result in breads too high in carbohydrate content, grossly low in protein and of poor physical quality.

African breadfruit is a tropical crop rich in high quality proteins, carbohydrate, fat, minerals, vitamins and fibre; and contains appreciable amount of many phytochemicals such flavonoids, polyphenols, anthoquinones, saponin and cardiac glycosides (Osabor et al., 2009). It has been used severally in developing biscuit, breakfast meals and complementary foods (Nwabueze and Atonwu, 2007).

Sweet potato is an important part of the people's diet in Nigeria, eaten boiled, fried, roasted or cooked with micro-oven. Nigeria is the leading producer of the crop in Africa. The orange-fleshed sweet potato variety is high in vitamins B₆ and C, the carotenoids, particularly the β -carotene, a pro vitamin A for good vision. In this study, flours of orange-fleshed sweet potato and sprouted African breadfruit were blended with the commercial flour to improve quality of bread to benefit consumers, and add value to the indigenous crops.

Materials and Methods

Materials: Commercial bakery flour and fresh African breadfruit (*Treculia Africana*) seeds were purchased from NdiOru main market, Ikwuoao-Umuahia while orange-fleshed sweet potato was from National Root Crop Research Institute (NRCRI), Umudike, all in Abia State, Nigeria. All reagents used were of analytical quality and were obtained from government-certified analytical grade chemical agent (LAVANS Chemical Nig. Ltd.).

Processing of orange-fleshed sweet potato flour (OFSP): Fresh orange-fleshed sweet potato roots were washed, peeled, sliced into 2 – 3cm dices, and then blanched for 5 min in alkaline solutions (3% Na₂CO₃) and then processed into OFSP flour.

Processing of sprouted African breadfruit seed four (ABF): Wholesome seeds (1.5 kg) were washed in 2% salt (NaCl) solution, and steeped in excess clean water at room temperature (26 ± 2 °C) for 18 h. Seeds were washed out of water, sprouted for 72 h, rasped in water between palms to remove radicles and hulls. The nibs were parboiled for 15 min, drained out of water, oven-dried (55 °C, 12 h) in hot air oven (Uniscope, SM-30-SS) and then milled into flour.

Formulation of composite flours and the bread making process: Orange-fleshed sweet potato (OFSP) and African breadfruit seed (ABF) flours were blended with commercial flour at 20 and 5 [SF2], 15 and 10 [SF3], 10 and 15 [SF4], 5 and 20 [SF5]; and 12.5 and 12.5% [SF6] respectively. The commercial flour served as a control [SF1]. Each blend was mixed in a Kenwood mixer (Kenwood 10F20, China) for 5 minutes, allowed to cool and then transferred to holding bowels.

Six bread samples were baked using straight dough method. First, all ingredients (100 g of each flour, 35 g sugar, 35 g shortening, 3 g yeast and 1.0 g salt) for each sample were weighed, mixed and kneaded with added water to form finished bread dough. Dough was covered with muslin cloth and kept for bulk fermentation for 1 h at room temperature (26 ± 2 °C) and 83% relative humidity. Dough was scaled at 75 g portions, molded into bread pans and proofed for another 45 min. before baking at 190 °C for 30 min in the baking oven. After baking, loaves were removed from the pans, cool naturally at room temperature, and then packaged in white polyethylene bags. These were stored in the food cupboard and analysed the next day.

Analysis of flour functional properties: Functional properties of flours were determined using standard methods. Water and Oil Absorption Capacity (WAC and OAC), foaming capacity (FC) and stability (FS) were determined using the method of Paredes-Lopez *et al.* (1991); gelation capacity (GC) and gelatinization temperature were as described by Coffman and Garcia (1977) while emulsion capacity was as per Predoche *et al.* (2014),

Proximate analysis: Proximate analysis, including moisture, ash, crude protein, fibre, fat contents, on bread samples was carried out using AOAC method of 2010. Carbohydrate was calculated by difference, $100 - (\% \text{ moisture} + \% \text{ Ash} + \% \text{ Crude protein} + \% \text{ Fibre} + \% \text{ Fat})$. Energy values were calculated using the Atwater factor with 1 g protein, 1 g carbohydrate, 1 g fat having energy values of 4 Kcal, 4 Kcal and 9 Kcal respectively (1 Kcal = 4.286 K Joules)

Bread physical quality analysis: Loaf weight was determined the next day by electronic weighing, its volume by pearl millet (instead of rapeseed) displacement method; and specific volume by dividing loaf volume by loaf weight (Nwabueze and Atonwu, 2007).

Results and Discussion

Functional properties of flours

Table 1 shows functional properties of Nigerian commercial bakery flour (the control) and its composite with different levels of orange-fleshed sweet potato (OFSP) and African breadfruit seed flours (ABF). Bulk density increased with OFP but decreased conversely with ABF; and ranged from 0.81 in SF3 to 76 g/ml in SF6. It was reported that higher value of 0.91-1.10 in composite flours from malted sorghum and wheat. Higher bulk density is desirable for easier dispensability of liquids in dough and batters (Nasr and Abufoul, 2004).

Wettability (WET) was 44.62 sec in control flour, 42.23 sec in SF2 but was higher and ranged from 46.95 sec – 47.97 sec in other experimental flours. WET depicts levels of surface tension, adhesive and cohesive forces between the flour particles and the surfaces. Gelatinization temperature (GT) increased with both OFSP and ABF in the flours.

Oil absorption capacity (OAC) of control flour, SF1, was 1.42 g/ml, improved with OFSP and ABF to 1.53 mg/ml in SB2 and to 1.72 (as high as 30% increase) in SF6. Higher OAC suggests presence of apolar amino acids and high emulsifying capacity of the flour. Flour with high oil absorption capacity enhances flavour and mouth feels in bakery goods. Lower value

of OAC ranging from 1.59-2.14% was reported in composite flours of wheat, sweet potato and hamburger bean (Okpala et al., 2013).

Water absorption capacity (WAC) increased with increasing ABF, was 1.81 g/ml in control flour, and ranged from 1.53 to 2.14 g/ml in experimental flours. WAC is affected by differences in protein concentrations and conformations, their interaction with water; and loss of association of amylose and amylopectin in native starch granules and structure (Nasr and Abufoul, 2004).

Emulsion capacity (EC) increased with both OFP and ABF addition; was 44.62% in control flour, 46.95% in SF3 and 47.97% in SF5. High EC improve dough handling and overall product quality of cookies and bread. Higher values of EC were of 15.10-52.10% were reported in composite flours of African yam bean and wheat; and 15.67-46.33% in composite flours of germinated pigeon pea, fermented sorghum and cocoyam (Okpala et al., 2013).

Table 1: Functional properties of commercial flour and its blends of orange-fleshed sweet potato (OSP) and sprouted African breadfruit seed (ABF) flours

Flours	BD [g/ml]	GT [°C]	WET [Sec]	OAC [g/ml]	WAC [g/ml]	EC [%]
SF1	0.78 ^{ab} ±0.01	76.51 ^a ±0.01	21.29 ^a ±0.01	1.42 ^a ±0.01	1.81 ^a ±0.01	44.62 ^a ±0.01
SF2	0.78 ^{ab} ±0.00	77.45 ^a ±0.01	23.02 ^a ±0.03	1.53 ^a ±0.01	2.01 ^a ±0.01	42.23 ^a ±0.02
SF3	0.81 ^a ±0.01	77.82 ^a ±0.01	23.89 ^a ±0.01	1.61 ^a ±0.01	2.06 ^a ±0.01	46.95 ^a ±0.01
SF4	0.82 ^a ±0.03	78.14 ^a ±0.01	25.63 ^a ±0.02	1.64 ^{bc} ±0.03	2.10 ^{ab} ±0.01	47.76 ^a ±0.01
SF5	0.79 ^{ab} ±0.01	78.54 ^b ±0.01	26.18 ^b ±0.01	1.67 ^{ab} ±0.01	2.14 ^a ±0.01	47.97 ^a ±0.01
SF6	0.76 ^b ±0.01	78.97 ^a ±0.01	26.92 ^a ±0.01	1.72 ^a ±0.02	2.12 ^a ±0.03	47.92 ^b ±0.02

OFSP = Orange-fleshed sweet potato, ABF= Sprouted African breadfruit seed, SF1= 100% wheat flour, SF2= 20% OFSP /5% ABF composite flour, SF3= 15% OFSP /10% ABF composite flour, SF4=10% OFSP /15% ABF composite flour, SF5= 5% OFSP / 20% ABF composite flour, SF6 = 12.5% OFSP/ 12.5% ABF composite flour, BD = bulk density, GT = gelatinization temperature, WET =wettability, AOC = oil absorption capacity, WAC = water absorption capacity, EC = emulsion capacity.

Proximate composition, energy value and loaf specific value of bread samples

Table 2 shows proximate composition, energy value and loaf volume of six bread samples with different levels of OFSP and ABF. The moisture content ranged from 19.28% to 19.79% in the bread samples. There was practically no difference in moisture contents of the bread

samples. This implies equal hydrogen bonds and Van Der Waal forces between water and food macromolecules among the bread samples.

However, addition of African breadfruit seed flours significantly ($p < 0.05$) increased crude protein, fibre and ash contents of bread samples. Protein content of SB1, the control bread was 11.32%; this decreased to 9.69% in SC3 (15% OFSP and 10% ABF) but increased to 12.57% in SD4 (10% OFSP and 15% ABF). Orange-fleshed sweet potato decreased protein content. However, at equal 12.5% addition of both OFSP and ABF in SF6, protein content was highest, 17.19%, in the sample. Similar trends of changes in protein content were also observed in ash content of the bread samples. The ash content of 1.42%, in the control bread, SA1 decreased to 1.37% in SC3 but increased to 1.48% in SD4. Ash content was highest at 1.73% in SF6 which had equal 12.5% OFSP and ABF additions. This implies that OFSP was low in protein while ABF was relatively rich in protein; ABF improved both protein and ash contents while OFSP improved ash content, not protein.

Crude fibre increased significantly ($p < 0.05$) across all the bread samples with addition of OFSP and ABF. Crude fibre content was 0.74% in the 100% wheat flour, SA1 but increased astronomically to 1.92% in SB2 (with 20% OFSP and 5% ABF flours) and finally to 3.71% in SF6 which had equal 12.5% of OFSP and ABF. Crude fat content increased significantly ($p < 0.05$) with ABF in the bread samples, but ranged from 3.04 to 3.24% in the samples. Breads were good sources of energy which ranged from 316.87 to 328.70 Kcal.

Specific loaf volumes (SLV) increased significantly ($p < 0.05$) with decreasing OFSP and increasing ABF in the flours. High SLV implies good functionality of flours during dough formation and bread baking. Bread sample SF6, with equal 12.5% of OFSP and ABF, had the highest LSV of 2.72; the control bread had 2.69. Addition of 12.5% each of OFSP and ABF are recommended for a better physical quality of bread.

Table 2: Proximate composition, energy value and loaf specific value of bread samples

Parameters	Bread samples					
	SA1	SB2	SC3	SD4	SE5	SF6
MC [%]	19.72 ^{ab} ±0.35	19.79 ^a ±0.18	19.45 ^{ab} ±0.07	19.45 ^{ab} ±0.14	19.33 ^{ab} ±0.16	19.28 ^b ±0.08
CP [%]	11.32 ^a ±0.01	9.77 ^a ±0.01	9.69 ^a ±0.03	12.57 ^a ±0.03	14.45 ^b ±0.03	17.19 ^a ±0.14
Fat [%]	3.24 ^a ±0.01	3.11 ^b ±0.03	3.06 ^a ±0.01	3.04 ^a ±0.01	3.13 ^b ±0.03	3.15 ^b ±0.01
CF [%]	0.74 ^a ±0.03	1.92 ^a ±0.01	3.09 ^a ±0.03	3.54 ^b ±0.01	3.67 ^a ±0.01	3.71 ^a ±0.01
ASH [%]	1.42 ^a ±0.02	1.30 ^a ±0.01	1.37 ^a ±0.01	1.48 ^a ±0.01	1.62 ^a ±0.03	1.73 ^a ±0.01
CHO [%]	63.57 ^b ±0.40	64.11 ^a ±0.17	63.34 ^b ±0.07	59.92 ^a ±0.16	57.80 ^a ±0.21	57.80 ^a ±0.21
EV [Kcal]	328.70 ^a ±1.54	323.51 ^b ±0.88	319.66 ^a ±0.27	317.32 ^a ±0.64	317.19 ^a ±0.96	316.87 ^a ±0.52
LSV [cm ³ /g]	2.69 ^{ab} ±0.58	2.59 ^a ±0.02	2.32 ^a ±0.32	2.66 ^b ±0.71	2.39 ^a ±0.35	2.72 ^{ab} ±0.66

OFSP – Orange-fleshed sweet potato flour, ABF-Sprouted African breadfruit seed flour, MC= moisture content, CP= crude protein, CF= crude fat, CHO= carbohydrate content, EV= energy value, LSV= Loaf specific volume, SA1=100% wheat bread, SB2= 20% OFSP / 5% ABF bread, SC3=15% OFSP / 10% ABF bread, SD4= 10% OFSP / 15% ABF bread, SE5= 5% OFSP / 20% ABF bread, SF6 = 12.5% OFSP / 12.5% ABF bread.

Conclusion

Both orange-fleshed sweet potato (OFSP) and African bread fruit (ABF) seed flours improved functional properties of Nigerian flour, nutrient composition and physical quality of bread. ABF improved crude protein and fat while both OFSP and ABF improved dietary fibre and ash contents of bread samples. Experimental and control breads were acceptable by the sensory panelists. Addition of both OFSP and ABF at equal levels of 12.5% in the flour produced bread of experimental bread that is of comparatively higher quality than the control.

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ORANGE-FLESHED SWEET POTATO AND AFRICAN BREADFRUIT AS FUNCTIONAL INGREDIENTS FOR IMPROVED MICRONUTRIENTS OF NIGERIAN BREAD

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Abstract

Orange-fleshed sweet potato (OFSP) and African breadfruit (ABF) are Nigerian food crops rich in essential micronutrients limiting in most Nigerian staples and diets. OFSP is specifically rich in pro-vitamin A. Their inclusion in bakery flour would improve both mineral and vitamin contents of Nigerian bread to benefit consumers nutritionally. This will also add value to these food crops industrially. Sprouted ABF seeds and OFSP roots were processed into flours; blended (%) with Nigerian bakery flour at 0 and 0, 20 and 5, 15 and 10, 10 and 15, 5 and 20; and 12.5 and 12.5 % and then baked into breads. Breads were analysed for quality. Both OFSP and ABF enhanced bread quality. Mineral and vitamin contents improved significantly ($p < 0.05$) with OFSP and ABF addition. The control bread had 1.63mg/100g β -carotene and 0.58mg/100g vitamin B₁ but addition of OFSP and ABF improved these constituents to 148.09 - 157.37mg/100g, and 0.67 - 0.97 respectively (mg/100g) contents of 1.63 and 0.58 in the control bread improved to 148.09 - 157.37, and 0.67 - 0.97mg/100g respectively. Experimental breads had comparable sensory scores with the control bread; bread with equal amount of OFSP and ABF (SF6 with 12.5% each of OFSP and ABF) was the most acceptable of all the bread samples.

Key words: Orange-fleshed potato, African breadfruit, fortification, bread quality.

Introduction

Major nutritional problems in a larger population could be solved by incorporating indigenously rich food crops into widely consumed food products. Most micronutrients are limiting in many Nigerian staples and diets. Bread is such a widely accepted product consumed by all ages and classes that could be used to address such nutritional problems. In Nigeria, bread has become the second most widely consumed food product after rice in most homes, restaurants and hotels (Olapade and Oluwole, 2013). It is eaten as snack and staple, although a starchy food. Indigenous crops rich in nutrients limiting in common Nigerian staples and diets could

be easily incorporated in commercial breads to benefit the wider population. Commercial flour used in this study had 20% cassava flour. This was in line with government regulation that commercial bakery flours in Nigeria must contain 10 – 20% of cassava flour in order to reduce high cost of wheat importation and also encourage local content in bread (Shittu, Raji and Sanni; 2007).

African breadfruit is a tropical crop. The seed is rich in high quality proteins, carbohydrate, fat, minerals, vitamins and fibre (Onwa et al., 2009); and contains appreciable amount of many phytochemical such flavonoids, polyphenols, anthoquinones, saponin and cardiac glycosides (Osabor et al., 2009). It has been used severally in developing biscuit, breakfast meals and complementary foods. Also, orange-fleshed sweet potato is a root food crop high in vitamins B₆ and C, carotenoids, particularly the β -carotene, a pro vitamin A, for good vision (FAO, 1990). In this study orange-fleshed sweet potato (OFSP) and African breadfruit seed (ABF) flours were blended with the Nigerian bakery flour to improve micronutrient contents of commercial bread to benefit the common Nigerians.

Materials and Methods

Materials: Commercial bakery flour and fresh African breadfruit (*Treculia Africana*) seeds were purchased from NdiOru main market, Ikwuoao-Umuahia while orange-fleshed sweet potato from National Root Crop Research Institute (NRCRI) Umudike, all in Abia State, Nigeria. All reagents used were of analytical quality and were obtained from government-certified analytical grade chemical agent (LAVANS Chemical Nig. Ltd.).

Production of orange-fleshed sweet potato flour (OFSP): Fresh orange-fleshed sweet potato roots were washed, peeled, sliced into 2 – 3cm dices, and then blanched for 5 min in alkaline solutions (3% Na₂CO₃) These were drained out of water, dried in Hot Air Oven (60°C, 24 h) (Uniscope, SM-30-SS), milled into fine OFSP flour and package for use.

Processing of sprouted African breadfruit seed flour: African breadfruit seeds (1.5 kg) were sorted, washed in 2% salt (NaCl) solution to prevent mold growth, and steeped in three times its volume of clean water at room temperature (26 ± 2 °C) for 18 h with changing of water at 6 h intervals. Seeds were washed out of water, spread on a jute bag support on raised platform and covered with a muslin cloth in airy laboratory bench. Water was sprinkled on seeds twice daily to facilitate sprouting within 72 h. The sprouted seeds were parboiled for 15 min, drained out of water and oven-dried (55 °C, 6 8 h) in hot air oven (Uniscope, SM-30-SS), Seeds were rasped between palm to remove ridicules and then de-hulled in a colloid mill. The hulls were winnowed away; and nibs oven-dried (55 °C, 12 h) in hot air oven (Uniscope, SM-30-SS) and milled into flour.

Formulation of Composite flours and the bread making process: Orange-fleshed sweet potato (OFSP) and African breadfruit seed (ABF) flours were blended with commercial bakery flour at 20 and 5 [SF2], 15 and 10 [SF3], 10 and 15 (SF4), 5 and 20 [SF5]; and 12.5 and 12.5%

[SF6] respectively. The commercial flour served as a control (SF1). Each blend was used for a bread sample.

Bread samples were prepared using straight dough method. First, all ingredients were weighed (100 g of each flour, 35 g sugar, 35 g shortening, 3 g yeast and 1.0 g salt), mixed together for 5 minutes in a Kenwood mixer (Kenwood 10F20, China), allowed to cool and kneaded uniformly by adding water to form finished bread dough. The dough was covered with muslin cloth for bulk fermentation for about 1 h at room temperature (26 ± 2 °C) and at 83% relative humidity. Afterwards, the dough was scaled at 75 g and molded into bread pans, covered again with muslin cloth for second proving for another 45 min. Baking was done at 190 °C for 30 min in the baking oven. After baking, bread samples were removed from the pans and allowed to cool at room temperature. Bread loaves were packaged in white polyethylene bags and stored in the food cupboard for quality analysis the next day.

Micronutrient determination

Vitamin C content was determined using the 2, 6-dihloro-indophenol titration method (Kirk and Sawyer, 1988). B-carotene (pro-vitamin A) content was determined using method of the Association of Vitamin Chemist (Kirk and Sawyer, 1988). Thiamine (B₁) and niacin (B₃) contents were determined as described by Okwu and Ndu (2006).

Mineral contents were determined using AOAC method of 2010. Five grams (5 g) of each bread sample was ashed in a muffle furnace (500 °C, 2 h); resultant ashes dissolved in 5 ml of HNO₃/HCl/H₂O (1:2:3) and heated gently until brown fumes disappeared. Then, 5 ml of deionized water was added and the mixture heated until colourless solution resulted. The solution was transferred to a 100ml volumetric flask and made up to the mark with deionised water. This was used for elemental analysis with the appropriate lamps and wavelengths using Atomic Absorption Spectrophotometer (AAS). Phosphorus content was analyzed by the molybdo-vandate colorimetric method

Sensory evaluation of bread: Sensory evaluation of bread samples was carried out by 20 semi-trained panelists using a 9-point hedonic scale ranging from 9=extremely like to 1=extremely dislike. Five to six slices of bread samples were presented in 3-digits coded white saucers for panelists to observe physical appearance, take bites and chew gradually; take second and third bites and chew continually; observe and grade parameters on the score sheet. Each panelist was given distilled water to rinse mouth in-between tests to avoid carry-over tastes.

Statistical analysis: Data were subjected to descriptive statistics and differences among means compared using analysis of Variance (ANOVA). Means where significantly different at $P < 0.05$ were separated using Fisher's least significant difference (LSD).

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Statistical analysis: Data were subjected to descriptive statistics and differences among means compared using analysis of Variance (ANOVA). Means where significantly different at $P < 0.05$ were separated using Fisher's least significant difference (LSD).

Table 1: Mineral and vitamin composition of bread samples produced with different levels Orange-fleshed sweet potato and sprouted African breadfruit flours

Bread Sample	Phosphorous [Mg/100g]	Calcium [Mg/100g]	Iron [Mg/100g]	Magnesium [Mg/100g]	Zinc [Mg/100g]	Potassium [Mg/100g]
SA1	71.42 ^f ±0.01	15.10 ^f ±0.01	0.97 ^e ±0.01	25.81 ^f ±0.01	0.94 ^f ±0.01	159.90 ^a ±0.01
SB2	120.28 ^a ±0.01	98.65 ^a ±0.01	1.21 ^a ±0.01	50.63 ^a ±0.01	1.18 ^a ±0.01	248.98 ^a ±0.01
SC3	122.19 ^a ±0.01	98.42 ^b ±0.01	1.41 ^b ±0.01	50.29 ^b ±0.01	1.24 ^a ±0.01	248.89 ^b ±0.01
SD4	123.76 ^c ±0.01	98.20 ^c ±0.03	1.11 ^b ±0.01	50.04 ^c ±0.02	1.32 ^a ±0.01	248.83 ^c ±0.01
SE5	126.51 ^b ±0.01	96.52 ^a ±0.03	1.09 ^a ±0.01	49.68 ^a ±0.01	1.39 ^b ±0.01	248.91 ^b ±0.01
SF6	128.16 ^a ±0.01	95.84 ^a ±0.01	1.05 ^a ±0.003	49.32 ^a ±0.01	1.43 ^a ±0.01	248.85 ^c ±0.01
Bread Sample	B-carotene [mg/100g]	Vitamin B₁ [mg/100g]	Vitamin C [mg/100g]			
SA1	1.63 ^f ±0.03	0.58 ^e ±0.01	10.88 ^a ±0.02			
SB2	157.37 ^a ±0.01	0.67 ^a ±0.01	10.61 ^a ±0.01			
SC3	155.72 ^b ±0.01	0.72 ^c ±0.01	10.44 ^f ±0.02			
SD4	152.54 ^c ±0.01	0.93 ^b ±0.01	10.95 ^c ±0.02			
SE5	149.25 ^a ±0.01	0.94 ^a ±0.01	11.03 ^b ±0.01			
SF6	148.09 ^e ±0.03	0.97 ^a ±0.01	11.13 ^a ±0.01			

OFSP – Orange-fleshed sweet potato flour, ABF-Sprouted African breadfruit seed flour, SA1=control bread with 100% commercial flour, SB2= 20% OFSP flour and 5% ABF flour bread, SC3=15% OFSP flour and 10% ABF flour bread, SD4= 10% OFSP flour and 15% ABF flour bread, SE5= 5% OFSP flour and 20% ABF flour bread, SF6 = 12.5% OFSP flour and 12.5% ABF flour bread.

Sensory properties of bread samples

Table 2 shows that addition of both orange-fleshed sweet potato (OSP) and African bread fruit seed flours (ABF) significantly ($p < 0.05$) affected sensory properties of bread samples.

ABF improved while OSP decreased the sensory quality of bread. However, all the bread samples were acceptable to the panelists as all had sensory scores of 5 and above, very much higher than the mid-mark (4.5) of the 9-point scale. At 12.5% equal addition of both OSP and ABF, bread sample SF6 had sensory score significantly similar ($p > 0.05$) to those of the control, SF1. Thus, both OSP and ABF could be used to fortify wheat for acceptable commercial bread in Nigeria. Addition of 12.5% of both OSP and ABF gave the best composite bread. This would reduce cost of bread, amount of imported wheat, and add value to these indigenous crops.

Table 2: Sensory properties of Bread Samples

Bread Sample	Crust colour	Crumb grain	Crumb texture	Crumb colour	Flavour	Overall Acceptance
SA1	7.25 ^a ±1.12	6.60 ^{ab} ±1.23	6.60 ^{ab} ±1.47	7.35 ^a ±1.04	6.00 ^a ±1.49	6.00 ^{ab} ±1.81
SB2	6.15 ^b ±1.73	5.95 ^b ±1.43	5.70 ^b ±1.92	6.00 ^b ±1.59	5.50 ^b ±1.54	5.15 ^b ±1.73
SC3	6.95 ^{ab} ±1.28	6.50 ^{ab} ±1.22	6.45 ^{ab} ±1.47	6.75 ^{ab} ±1.71	6.05 ^{ab} ±1.50	6.15 ^{ab} ±1.63
SD4	7.15 ^{ab} ±1.27	6.85 ^{ab} ±1.35	6.65 ^{ab} ±1.47	6.95 ^{ab} ±1.57	6.45 ^{ab} ±1.73	6.20 ^{ab} ±1.67
SE5	6.15 ^b ±2.11	6.45 ^{ab} ±1.61	6.45 ^{ab} ±1.61	6.45 ^{ab} ±2.11	5.60 ^b ±2.06	5.55 ^{ab} ±2.04
SF6	7.03 ^a ±1.22	7.05 ^a ±1.23	7.15 ^a ±1.04	7.35 ^a ±1.39	6.90 ^a ±1.45	6.80 ^a ±1.99

OFSP – Orange-fleshed sweet potato flour, ABF-Sprouted African breadfruit seed flour, SA1=100% wheat flour bread, SB2= 20% OFSP flour and 5% ABF flour bread, SC3=15% OFSP flour and 10% ABF flour bread, SD4= 10% OFSP flour and 15% ABF flour bread, SE5= 5% OFSP flour and 20% ABF flour bread, SF6 = 12.5% OFSP flour and 12.5% ABF flour bread.

Conclusion

The control and all the experimental breads were acceptable to the consumer as all sensory scores ranged from 5.15 to 7.35. Both orange-fleshed sweet potato and sprouted African breadfruit seed flours improved mineral and vitamin contents of bread and did not significantly ($p < 0.05$) affect sensory scores of bread at 12.5% equal addition of both. Experimental bread with 12.55 of OFSP and ABF had the best micronutrient composition and sensory scores; and is recommended the best among the samples.

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SENSORY PROPERTIES OF CHIN-CHIN PRODUCED WITH HIGH QUALITY CASSAVA FLOUR FROM VARIETIES OF LOW POSTHARVEST PHYSIOLOGICALLY DETERIORATED CASSAVA

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Abstract

Sensory properties of chin-chin produced with high quality cassava flours (HQCFs) from varieties of low postharvest physiologically deteriorated (PPD) cassava flours were investigated. Wholesome four varieties of yellow-fleshed Low PPD cassava (IITA-TMS-IBA011368, IITA-TMS-IBA070596, IITA-TMS-IBA011412, IITA-TMS-IBA011371) and one variety of high PPD cassava roots (TMEB419, white) were processed into HQCFs. The chin-chin produced with HQCF from five varieties of cassava was analyzed for sensory properties. Pertinent data obtained were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS version 25.0) and significant means were separated using Duncan Multiple Range Test. The mean sensory properties of the chin-chin ranged from 2.00 to 4.26 for appearance, 2.00 to 3.84 for texture, 2.80 to 3.21 for aroma, 2.10 to 4.83 for crispiness, 2.10 to 3.47 for taste and overall acceptability was 2.25 to 4.32. Acceptable chin-chin comparable to the one prepared with wheat flour were produced from low PPD cassava flour; chin-chin prepared with IITA-TMS-BA011368 was the most preferred.

Keywords: Chin-chin, Sensory properties, Cassava flour, Physiological deterioration, Crispiness.

Introduction

Sensory descriptive analysis of food products provides an understanding and control of the key attributes for consumer satisfaction and for market success (Hough, 2010). Although sensory characteristics are subjective, they provide pertinent information important for overall understanding of food consumption, preference and acceptability. Consumer acceptance is crucial for the market success of new food products.

Screening of available varieties of cassava roots for low PPD was considered a priority with the view to extending the postharvest life of cassava root from two days (48hrs) to 5 days (120hrs), enhancement of its nutritional value with pro-vitamin A or β -carotene that has

propensity to prevent oxidation (anti-oxidative effect) and widening the functionality of its products (starch and flour). Researchers had established that varietal differences affects quality characteristics like physical, functional and chemical properties of high quality cassava flour, indicating that flour quality and uses also differs (Alimi *et al.*, 2021).

Low postharvest physiologically deteriorated (PPD) cassava (*Manihot esculenta*) is a promising crop owing to its high gel strength, starch granule stability to heating, low peak time and tendency for retrogradation characteristics and good physical properties such as appealing yellow color that constitute appeal which could influence consumer preference when applied in baked food products such as cake, bread etc. (Alimi *et al.*, 2021).

In Nigeria, crops such as cassava, cowpea etc. and their flours have been explored and prospected for use in replacing wheat flour up to 30% so as to reduce the over-dependence on wheat importation for use as food and in industrial application (Alimiet *al.*, 2016). The use of CF as partial substitute to wheat flour for baking purposes has received the support of the Federal Government of Nigeria, which mandated the flour mills to include up to 10% high quality cassava flour (HQCF) into wheat flour for baking purposes.

The incidence of celiac diseases has necessitated prospecting gluten-free flour such as cassava flour for baking purposes. Celiac disease represents an autoimmune disease induced by gliadin and related prolamins present in gluten of wheat, barley and rye grains (Maki, 2008). High quality cassava flour from low postharvest physiological deteriorated cassava is a gluten-free flour that could be beneficial for celiac patients (Biagi *et al.*, 2009). One of the most popular food uses of cassava flour (CF) worldwide is in the manufacture of baked product such as bread but now prospected for cookies, biscuits, chin-chin and cake baking (Alimi *et al.*, 2016).

Chin-chin is a fried snack popular in Nigeria and West Africa. It is sweet, hard, doughnut-like baked or fried dough of wheat flour. Chin-chin may also contain cowpeas. Many people bake it with ground nutmeg for flavor. It is usually kneaded and cut into small squares of one square inch or to about a quarter of an inch thick before frying. This can be served as a side dish and makes an ideal savoury snack with drinks at parties or simply in between meals (Mepba *et al.*, 2007). This study was conducted to investigate the sensory properties of chin-chin prepared with high quality cassava flour from low postharvest physiologically deteriorated (PPD) cassava.

Materials and Methods

Materials

Flours from five (5) varieties of cassava were used for the study. Four yellow fleshed varieties screened for low postharvest physiological deterioration were: IITA-TMS-IBA011368 (yellow), IITA-TMS-IBA070596 (yellow), IITA-TMS-IBA011412 (yellow), IITA-TMS-IBA011371 (yellow) and one variety of high postharvest physiological deterioration cassava

(TMEB419, white) were provided by International Institute of Tropical Agriculture (IITA), Ibadan.

Production of cassava flour used in the study

Wholesome cassava tubers used for this study were provided by IITA which were processed into HQCF following the protocol described by Iwe *et al.* (2017).

Formulation and preparation of chin-chin

The recipe for the production of chin-chin is presented in Table 1. The method described by Oke *et al.* (2017) was adopted with slight modification. One-quarter measure of the cassava flour from each variety was pre-gelatinized. Processed cassava flour from each cassava variety (300g), sugar (80g), margarine (30g), baking powder (10g), eggs (90g), and cinnamon (0.5g) were thoroughly dry mixed together at appropriate rate in a large bowl to achieve homogenous mixing. The pre-gelatinized portion was admixed with the dried-mixed flour and was thoroughly mixed together to make fairly stiff dough. After mixing, the stiff dough was rolled tightly to 1cm thickness on a board and cut into small cubes. Cut dough was fried in a deep hot vegetable oil until golden brown at 190 °C for 10 mins using deep fryer (Model: Moulimex). After frying, the chin-chin was allowed to cool, packed and sealed for subsequent analyses.

Sensory Evaluation

The method described by Iwe, (2002) was adapted. The sensory panel consisted of twenty trained panelists and regular consumers of chin-chin who were asked to score the chin-chin using a 9-point hedonic scale based on their degree of likeness where 1= like extremely; 5= neither like nor dislike; 9= dislike extremely. Chin-chin attributes evaluated were: Appearance, texture, aroma, color, crispness, taste and overall acceptability

Statistical analysis

The sensory attributes data obtained were subjected to analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS) version 25.0 (SPSS Inc. USA) and significant means were separated using Duncan's Multiple Range Test.

Results and Discussion

Sensory properties of chin-chin prepared from low PPD cassava flours are presented in Table 1. Appearance of chin-chin prepared with high quality cassava flour from IITA-TMS-IBA011412 cassava and refined wheat (Control) flour were significantly different ($p < 0.05$) from each other. Appearance is the first characteristics perceived by the human senses and play an important role in the identification of quality and final preference in selection of food. The appearance of a food has shown impact on appetite stimulation or depression resulting

in pleasure or total depression. The look of a food impacts acceptance and preference, before the product touches the lips. The appearance score of 2.00 ± 0.86 , correspond to 'like very much' for the chin-chin sample C-070593 prepared with flour from IITA-TMS-IBA070593 cassava, which was rated highest while the chin-chin sample C-011412 prepared with flour from IITA-TMS-IBA011412 cassava was rated least with appearance score of 4.26 ± 1.8 , corresponding to 'like slightly' on the hedonic scale.

Texture is one of the most critical features of food and a required quality parameter in the acceptance of numerous food products. The texture score (2.00 ± 0.79) correspond to 'like very much' for the chin-chin sample C-070593 prepared with flour from IITA-TMS-IBA070593 cassava and was rated highest while the chin-chin sample C-011412 prepared with flour from IITA-TMS-IBA011412 cassava was rated least with texture score (3.84 ± 1.89) corresponding to 'like moderately' on the hedonic scale.

Aroma is appraised by smell of food and is important in the appreciation of food flavor. A pleasant smell signifies that such food is delicious and acceptable. The chin-chin prepared with the high quality cassava flours from varieties of cassava (low and high postharvest physiological deteriorated) and wheat flour were not significantly different ($p \leq 0.05$) in terms of aroma. The aroma score (2.80 ± 1.01) correspond to 'like very much' for the chin-chin sample C-011368 prepared with flour from IITA-TMS-IBA011368 cassava, which was rated highest while the chin-chin sample C-011371 prepared with flour from IITA-TMS-IBA011371 cassava was rated least with aroma score (3.14 ± 1.53) corresponding to 'like moderately' on the hedonic scale. Chin-chin sample C-011368 prepared with HQCF from IITA-TMS-IBA011368 cassava was preferred to chin-chin sample C-WHEAT prepared with refined wheat flour in terms of aroma as adjudged by the panelist. It was observed statistically that, there was no significant ($p > 0.05$) difference in the chin-chin samples (C-011368, C-070593, C-011412, C-011371 and C-419) prepared with cassava flours and (C-WHEAT) sample prepared with wheat flour in terms of aroma and this was expected because the same formulation was used in their preparation and this trend was different to what was reported by Oke *et al.* (2017) for sensory properties of chin-chin produced from wheat- tigernut- pomace blends.

The prepared chin-chin were not significantly ($p > 0.05$) different in terms of crispiness. The crispiness score (2.10 ± 0.72) which correspond to 'like very much' for the chin-chin sample C-011368 prepared with IITA-TMS-IBA011368 flour was rated highest while the chin-chin sample C-011412 prepared with IITA- IITA-TMS-IBA011412 cassava flour was rated least with crispiness score (4.83 ± 2.63) corresponding to 'like slightly' on the hedonic scale.

Taste helps in the identification, acceptance and appreciation of food product. The prepared chin-chin samples were significantly ($p < 0.05$) different in terms of taste. The taste score (2.10 ± 0.64) correspond to 'like very much' for the chin-chin sample C-011368 prepared with IITA-TMS-IBA011368 flour and was rated highest while the chin-chin sample C-011412 prepared with IITA-TMS-IBA011412 cassava flour was rated least with taste score (3.47 ± 2.07)

corresponding to 'like moderately' on the hedonic scale. The most acceptable chin-chin in terms of taste was C-011368, the one prepared with high quality cassava flour from IITA-TMS-IBA011368 cassava variety. Similar trend of results on taste of chin-chin have been reported by Akusuet *al.* (2016) for sensory evaluation of chin-chin prepared with the composite wheat-cocoyam flour.

Table 1: Mean (and standard deviation; n=20) of sensory properties of cassava chin-chin

Sample	App	Texture	Aroma	Crispiness	Taste	Ovaccp
C-011368	2.90±1.17 ^a	2.25±1.12 ^a	2.80±1.01 ^a	2.10±0.72 ^a	2.10±0.64 ^a	2.25±0.64 ^a
C-070593	2.00±0.86 ^a	2.00±0.79 ^a	2.95±0.99 ^a	2.30±1.17 ^a	2.60±1.05 ^{ab}	2.30±0.93 ^a
C-011412	4.26±1.80 ^b	3.84±1.89 ^b	3.21±1.58 ^a	4.83±2.63 ^b	3.47±2.07 ^b	4.32±1.97 ^b
C-011371	2.86±1.82 ^a	2.81±1.69 ^a	3.14±1.53 ^a	3.05±1.88 ^a	2.91±1.26 ^{ab}	2.91±1.38 ^a
C-419	2.90±1.85 ^a	2.95±1.80 ^{ab}	3.00±1.34 ^a	2.55±1.61 ^a	2.50±1.15 ^a	2.75±1.25 ^a
C-WHEAT	3.05±1.43 ^b	2.60±1.23 ^a	2.90±1.45 ^a	2.35±1.35 ^a	2.90±1.71 ^{ab}	2.90±1.83 ^a

Results are expressed as mean + standard deviation of 3 replicate samples. Mean values followed by different superscript letter within a column are significantly different ($p \leq 0.05$).

Key: Ovaccp: Overall acceptability; App: Appearance;

C-011368: Chin-chin baked with HQCF from IITA-TMS-IBA011368 cassava;

C-070593: Chin-chin baked with HQCF from IITA-TMS-IBA070593 cassava;

C-011412: Chin-chin baked with HQCF from IITA-TMS-IBA011412 cassava;

C-011371: Chin-chin baked with HQCF from IITA-TMS-IBA011371 cassava;

C-419: Chin-chin baked with HQCF from TMEB 419 cassava;

C-WHEAT: Chin-chin baked with flour from wheat

The chin-chin samples C-011368, C-070593, C-419, C-WHEAT and C-011371 prepared with high quality cassava flours from IITA-TMS-BA011368, IITA-TMS-IBA070593, TMEB 419, Control (wheat) and IITA-TMS-IBA011371 cassava respectively, were not significantly ($p > 0.05$) different in terms of overall acceptability as adjudged by the assessors. Chin-chin samples prepared with high quality cassava flour from low postharvest physiologically deteriorated cassava varieties compared favorably with that prepared with refined wheat flour but chin-chin sample C-011368 prepared with IITA-TMS-BA011368 was the most preferred.

Generally, it is pertinent to remark that chin-chin prepared with high quality cassava flours from varieties of low and high postharvest physiologically deteriorated cassava were comparable with chin-chin prepared with refined wheat flour in terms of sensorial properties such as aroma, color, crispiness, taste and overall acceptability.

Conclusion

The chin-chin prepared with high quality cassava flours (HQCFs) from selected low PPD cassava varieties were comparable to chin-chin prepared with wheat flour in terms of sensorial properties such as appearance, aroma, texture and overall acceptability. The chin-chin prepared with HQCF from IITA-TMS-BA011368 was the most preferred. The use of HQCF produced from low postharvest physiologically deteriorated cassava root may contribute to the pro-vitamin A (carotenoid) composition of chin-chin which may contribute to the reduction of vitamin A deficiency (VAD) and could enhance the utilization of this crop in sub-Saharan African countries like Nigeria where the crop has not been optimally utilized.

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**EVALUATION OF MINERAL AND TEXTURAL PROPERTIES OF EX-
TRUDED
SNACKS FROM MALTED SORGHUM AND GROUNDNUT FLOUR BLEND**

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Abstract

Ready-to-eat extruded snacks were produced from the mixtures of malted sorghum flour and groundnut, using extrusion technology in different combination of the ingredients. The mineral composition and the textural properties of the extruded snacks were investigated using standard methods. The potassium, calcium, magnesium and iron ranged from 3.46 -4.97, 8.01 – 10.12, 2.50 – 2.93 and 0.41 – 0.65mg/100g, respectively while the hardness, adhesiveness, cohesiveness, chewiness and gumminess ranged from 58.53 -91.77, 1.20 – 6.20, 0.10 – 0.34, 4.30 – 10.33 and 19.51 – 49.20 N, respectively. The addition of groundnut flour to sorghum increased the mineral content and this makes the blends better source of micronutrients. The research established that the use of malted sorghum with groundnut flour for the production of extruded snacks is achievable using extrusion technology.

Keywords: Sorghum, Groundnut, Extrusion, Snacks, Mineral

Introduction

Local raw materials substitution for wheat flour is increasing due to the growing market for confectioneries (Noor Aziah and Komathi, 2009). Thus, several developing countries have encouraged the initiation of programmes to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour (Abdelghafor *et al.*, 2011). There is a growing consumer interest in ready-to-eat snack foods mainly due to their convenience, wide availability, appearance, taste and texture. Population-based studies have shown increased food consumption related to the snacking habit (Nicklas *et al.*, 2003), these snacks may be tailored towards meeting the nutritional requirement of the populace (Agiringa and Iwe, 2009; Ibidapo *et al.*, 2017). A locally produced crop such as sorghum mixed together with groundnut as protein source can be used to manufacture this type of snacks. Extrusion technology has been used in many industries that produce new and unique snack foods due to advances in its technology compared to other traditional methods (Shah *et al.*, 2018). The use of composite flours in research and development have been worked on over the years with resultant successes (Giwa and Ikujenlola, 2012; Adebawale *et al.*, 2012; Hussain *et al.*, 2014; Ajatta *et al.*, 2016; Akoja and Coker, 2018). Sorghum, locally called guinea corn in Nigeria is a gluten-free grain that has the

potential to be used as an alternative to wheat flour. Nigeria is the number one producer of sorghum in Africa. The protein and starch in sorghum grain are more slowly digested than those from other cereals. Sorghum starch is gluten-free, making sorghum a good alternative to wheat flour for individuals suffering from celiac disease. Groundnut (*Arachis hypogaea* L.) is a major annual oil seed crop and a good source of protein (Asibuo *et al.*, 2008) in the tropics. Groundnut seed is a good source of protein and oil (Asibuo *et al.*, 2008; Eshunet *et al.*, 2013). It contains about 44%–55% of oil, 22%–30 % of protein. It also contains riboflavin, minerals (Ca, Mg, K), and vitamins (Savage and Keenan, 1994). Composite flour is a mixture of different flours from cereal, legume or root crops that is created to satisfy specific functional characteristics and nutrient composition (Bolarinwa *et al.*, 2015). The use of composite flours has some few advantages for developing countries such as Nigeria in terms of conserving foreign exchange, promoting high-yielding native plant species, a cheaper supply of protein for human nutrition and better overall use of domestic agriculture production (Bugusu *et al.*, 2001). This work is aimed at determining the mineral composition and textural properties of the extruded snacks produced from malted sorghum - groundnut composite flour.

Materials and methods

Sorghum and fresh groundnut were purchased from Kuto market in Abeokuta, Ogun state, Nigeria. Equipment such as milling machine, extruder were obtained from the food processing laboratory of Federal University of Agriculture, Abeokuta. The method of Bolarinwa *et al.* (2015) was used to prepare malted-sorghum flour. The sorghum grains (2 kg) were sorted to remove stones, dirt and other extraneous materials. The cleaned grains were thoroughly washed and steeped in water for 12 h. The hydrated grains were spread on a moist jute bag which had been previously sterilized by boiling for 30 minutes and the grains were allowed to germinate for three days. Germinated seeds were dried at 60°C in a cabinet dryer to a moisture content of 10-12%. The withered rootless grains were gently brushed off, and the malted grains were dry milled, sieved and packaged in an airtight container. Preparation of groundnut flour was done manually by first removing moldy, shriveled nuts and stones from groundnut grains, while the dust was removed by winnowing in a basket. The grains were dried using cabinet dryer at 60°C for 5 h to facilitate peeling of the testa and the testa was removed by rubbing in between palms. The groundnut was milled with the attrition milling machine to obtain the groundnut flour (Agriga and Iwe, 2009). Extruded snacks were produced according to the modified method of Kareem *et al.*, 2015. Minerals content were determined using standard methods (AOAC, 2000) and texture was also analyzed using the procedure described by Da Silva and Moreira (2008). Data obtained were subjected to analysis of variance (ANOVA) using SPSS version 21.0 and the differences between mean values were evaluated using Duncan's Multiple Range Test.

Results and Discussion

The results of the mineral composition of extruded snacks from blends of malted sorghum and groundnut is presented in Table 1. Potassium is nutritionally important in the maintenance of cellular water balance; pH regulation in the body and it is also associated with protein and carbohydrate metabolism (Onibon *et al.*, 2007), it has been reported to be an important mineral

that help in maintaining electrolyte balance in humans (NTBG, 2009). The potassium content of the extruded snacks ranged from 3.46 – 5.64 mg/10g which is in line with the findings of Ranya *et al.* (2013). Calcium plays important structural roles such as teeth and bone formation and maintenance. Moreover, it intervenes in various physiological and biochemical processes such as oxidative phosphorylation, enzyme activity, cell division, cell membrane function, hormone secretion, blood clotting, muscle contraction and transmission of nerve impulses (Adebanjo *et al.*, 2020). It ranged from 6.65 - 10.12 mg/100g with sample blend of malted sorghum and groundnut (60:40) having the highest while snack sample from blend of 70:30 malted sorghum and groundnut flour had the lowest. As groundnut flour increases, the calcium content of the extruded snacks increases significantly at ($p < 0.05$).

Table 1: Mineral Composition (%) of Malted Sorghum-Groundnut Extruded Snacks

Samples	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)
MS100	4.15 ± 0.01 ^b	7.88 ± 0.05 ^a	2.43 ± 0.00 ^a	0.61 ± 0.01 ^a
MS90G10	3.98 ± 0.01 ^a	8.22 ± 0.00 ^b	2.61 ± 0.00 ^a	0.57 ± 0.00 ^a
MS 80G20	4.32 ± 0.01 ^c	6.65 ± 0.00 ^a	2.81 ± 0.01 ^b	0.53 ± 0.00 ^a
MS70G30	3.46 ± 0.01 ^a	8.11 ± 0.00 ^b	2.92 ± 0.00 ^b	0.43 ± 0.00 ^b
MS60G40	5.64 ± 0.01 ^f	10.01 ± 0.00 ^d	4.96 ± 0.00 ^d	1.41 ± 0.001 ^a
W100	4.97 ± 0.02 ^c	10.12 ± 0.01 ^d	2.93 ± 0.00 ^c	0.65 ± 0.00 ^f

Values are means of triplicate determination, Mean values with different superscripts within the same column are significantly different ($p \leq 0.05$), MS = Malted sorghum flour, G= Groundnut flour W= Wheat flour

agnesium is required for the synthesis of proteins, the production of energy and muscle contraction (Moore, 2004), it also helps maintain electrical potential in nerves (Ferrao *et al.*, 2017). The mean values of magnesium content of the extruded snacks ranged from 2.43– 4.96 mg/100g. Magnesium value was seen to increase significantly ($p < 0.05$) as the groundnut flour increases. Iron is an essential macro-nutrient required for human growth, it is required for the synthesis of hemoglobin and myoglobin which are oxygen carrier in the blood and muscle respectively. Iron content of the extruded snacks also increased as the groundnut flour content increased with values ranging from 0.43– 1.41 mg/100g.

The effect of groundnut flour on the textural properties of malted sorghum-groundnut flour extruded snacks is shown in Table 2. Texture measurements can be very valuable for quality control and process optimization as well as for the development of new products with desirable properties and characteristics as reported by Aly and Seleem, (2015). The hardness value is the peak force that occurs during the first compression, it is the textural properties that

attract more attention in evaluation of baked food, because of its close association with human perception of freshness (Aly and Seleem, 2015). The hardness of the extruded snacks ranged from 58.53 - 91.77 N. The least hardness value was obtained from flour blend of 60% malted sorghum and 40% groundnut flour snacks.

Table 2: Texture profile analysis of extruded snacks developed from malted sorghum - groundnut flour blends

Samples	Hardness (N)	Adhesiveness (N)	Cohesiveness(N)	Chewiness (N)	Gumminess(N)
MS100	80.44 ±7.46 ^a	1.20 ± 0.76 ^a	0.10 ± 0.01 ^a	3.30 ± 0.48 ^a	19.51 ±1.94 ^a
MS90G10	71.70 ±12.25 ^a	3.61 ± 0.18 ^b	0.16 ± 0.01 ^b	7.88 ± 0.51 ^d	28.86 ± 0.40 ^b
MS 80G20	65.44 ±12.97 ^b	3.91 ± 0.08 ^{bc}	0.17 ± 0.02 ^{ab}	6.59 ± 0.30 ^c	37.17 ±1.39 ^c
MS70G30	61.54 ±11.19 ^b	4.83 ± 0.25 ^c	0.24 ± 0.01 ^c	6.92 ± 0.32 ^c	43.70 ± 2.87 ^d
MS60G40	58.53 ± 1.85 ^a	5.37 ± 0.04 ^d	0.34 ± 0.04 ^d	4.61 ± 0.40 ^{ab}	42.28 ±1.53 ^d
W100	91.77 ± 3.66 ^a	6.20 ± 0.01 ^a	0.42 ± 0.04 ^a	9.33 ± 0.17 ^a	49.20 ±1.46 ^a

Values are means of duplicate determination, Mean values with different superscripts within the same column are significantly different at $p \leq 0.05$, MS = Malted sorghum flour, G = Groundnut flour, W= wheat flour

The hardness was seen to decrease as the inclusion of groundnut flour increased in the extruded snacks. The decreasing trend in hardness on addition of groundnut flour was also observed by Srivastava et al. (2010) and Sujirtha and Mahendran (2015) and these decrease could be attributed to the fat retention in the groundnut flour. Aly and Seleem (2015) reported that adhesiveness is the maximum negative force generated during probe return. It increases significantly ($p < 0.05$) with increase in groundnut flour inclusion, it ranged from 1.20 - 6.20N and the highest value was obtained from experimental blends of 60 % malted sorghum and 40 % groundnut flour. Cohesiveness is the area of working during the second compression divided by the area of work during the first compression. It is how well a product withstands a second deformation relative to its resistance under the first deformation. Similarly, cohesive also increases significantly ($p < 0.05$) with increase in groundnut flour. In addition, chewiness describes the behaviour of the snacks during biting process. It also increases with increase in groundnut. However, the control sample containing 100 % malted sorghum flour was seen to have the lowest value of cohesiveness, chewiness and gumminess.

Conclusions

Substitution of malted-sorghum flour with 30% groundnut flour resulted in notable increased in mineral content with good textural properties. The results obtained in this study indicated that highly nutritious flour can be produced from malted sorghum-peanut composite flour.

Industrial production of this flour will greatly increase the utilization of sorghum and peanut in developing countries where the crops have not been utilized optimally.

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**PROXIMATE COMPOSITION AND SENSORY PROPERTIES OF BISCUITS
PREPARED FROM WHEAT-MAIZE COMPOSITE FLOUR ENRICHED WITH
FERMENTED *PARKIABIGLOBOSA* (AFRICAN LOCUST BEAN) COTYLEDON
FLOUR**

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Abstract

Concern of health-conscious consumer for quality food led to the enrichment of Biscuits prepared from wheat-maize composite flour with nutritive and medicinal underutilized crop such as *Parkiabiglobosa* cotyledons flour. Biscuits were produced from wheat-maize composite flours and enriched with fermented *Parkiabiglobosa* (FPB) cotyledons flour. The proximate composition and sensory properties of the FPB enriched wheat-maize composite flour biscuit samples (A, B and C) were assessed. The results of the enriched biscuits samples revealed moisture content (12.52-12.80%), ash (3.15-3.28%), fat (12.30-15.26%), fibre (2.63-4.21%), crude protein (10.37-13.26%) and carbohydrate (53.00-57.05%). The results of sensory evaluation ranged from 5.30-6.40; 4.70-5.70; 4.70-5.90; 4.60-5.70; and 4.82-5.87 for crispness, appearance, aroma, taste and overall acceptability respectively. There were no significant differences between the samples in terms of overall acceptability. Moreover, Sample C having 15% FPB, had highest value of fibre, protein and carbohydrate contents and was most preferred for crispness, taste and overall acceptability. This study advocates the need to add fermented *Parkia biglobosa* to wheat-maize composite flour biscuit to improve its nutritional content.

Keywords: *Parkiabiglobosa*, Biscuits, Fermented, Wheat–maize, Composite flour.

Introduction

Biscuits are described as non-fermented aerated mix variety of flour confectionary products which are eaten as snack or dessert (Zakari *et al.*, 2013). They are low moisture content snacks comparatively free from microbial spoilage which prolong their shelf- life (Zakari *et al.*, 2013; Adiza, 2020). They are classified either by the degree of fortification and processing or by the method adopted in shaping them (Zakari *et al.*, 2013). Biscuits are produced from soft cereals wheat cultivated in many parts of the world but imported by countries with unfavorable climatic conditions. Various composite flours had been developed from our indigenous food crop as wheat substitutes such as wheat-maize composite flour. Therefore, maize crops are used as composite flour to reduce postharvest losses. Maize is reported to have low protein (zein) and lack some essential amino acid; there is therefore need for fortification as health-

conscious consumers demand for quality, organic and nutritious foods (Adiza, 2020). *Parkia biglobosa* has been widely recognized as an important indigenous multipurpose fruit tree which can be utilized as food, medicine, manure, tannin, shade, bee food, stabilization of degraded environment, livestock feeds, fibre and several domestic uses (Musaraet *al.*, 2020). The commonest use of locust beans seed is used as seasoning and condiment in African countries such as Togo, Mali, Nigeria and Benin Republic (Ayo-Lawalet *al.*, 2011). The fermented seed, which is called *iru* or *dawadawa*, is a popular condiment known to be rich in protein and vitamins. Hence it was therefore reasoned that, local underutilized crop such as locust beans (*Parkia biglobosa*) seed cotyledons could be used in wheat-maize composite flour biscuit fortification due to its nutritional attributes. Therefore, the objective of this study was to produce biscuit from wheat-maize composite flour enriched with *Parkia biglobosa* flour and determine the proximate and sensory properties of the developed product.

Materials and methods

Wheat and maize grains, fermented *Parkia biglobosa*, baking powder and other baking ingredients were purchased from Oja-Oba Market, Ado-Ekiti. The experiment was carried out in the Processing Laboratory in the Department of Food Technology, Federal Polytechnic, Ado-Ekiti. Wheat flour and maize flour were produced as described by Onuegbuet *al.*, (2013) and Idowuet *al.*, (2021) methods were adapted in production of fermented *Parkia biglobosa* flour. The biscuit samples were produced based on the modified method described by Ihekoronye (2008).

The standard procedure of Association of Official Analytical Chemist International (AOAC, 2009) was used for the analysis of moisture content, ash, fat, protein, fibre and carbohydrate of the biscuit samples.

Biscuit samples were evaluated using nine-point hedonic scale. Staff and students of the Department of Food Technology, Federal Polytechnic Ado-Ekiti were used as taste panelists.

Laboratory analyses were carried out in triplicates. Data obtained were analyzed using ANOVA at 5% significance level. Means were separated using Turkey's Test using SPSS Statistical Product Service Solution Version 23.0

Results and Discussion

Proximate composition

The proximate compositions of the enriched biscuit samples and control are presented in Table 1. The moisture content of the enriched biscuit samples (A, B and C) ranged between 12.52 to 12.80%, Sample C had the highest value followed by sample A while sample B had the lowest moisture content 12.52%. The lower the moisture contents of a product, the longer the potential storage life of the product. It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content, for this reason, a water content of 10% is generally specified for flours and other related products (Eddy *et al.*, 2007). There were significant differences ($p < 0.05$) between the moisture content of the biscuit samples. The mean values of the ash content of the samples ranges from 3.15 to 3.28% Sample A (control) had the highest ash content and the lowest value was observed in sample B. The fat content ranged between 12.30 to 15.26%, sample A had the highest value while the lowest was observed in sample C. The fibre content ranged between 2.63 to 4.21%, sample A had the lowest fibre content while sample C had the highest content. This may be as a result of the inclusion level of the fermented *Parkia biglobosa* powder in the biscuit. The protein content ranged from 10.37 to 13.26%. Sample C had the highest protein content while sample A had the lowest value. The protein content of the biscuits shows that their consumption alone could improve protein-deficiency condition such as kwashiorkor. Carbohydrate content of the sample was within the range of 53.00 to 57.05%. Sample C had the highest while sample A had the lowest value. There were significant differences between the carbohydrate content of the flour sample at ($p < 0.05$). It was observed that protein, carbohydrate and fibre contents of the biscuits increased as the *Parkia biglobosa* content increased in the sample while fat content decreased. The results of the values obtained for ash content is a pointer to the quality of their mineral constituents. The increase in protein content is as a result of addition of fermented *Parkia biglobosa* flour in the biscuit compared to the lower content reported by Adanse *et al.*, (2020). Dietary fibre also has a lot of beneficial health in the prevention of some health threatening diseases e.g., constipation, bowel cancer, diabetes and heart disease Veronese *et al.*, (2018).

Table 1: Proximate composition of fermented *Pakia biglobosa* (locust beans) enriched wheat-maize composite flour biscuits

Samples	Moisture content	Ash	Fat	Fibre	Protein	Carbohydrate
A	12.64±0.02 ^{ab}	3.28±0.02 ^a	15.26±0.02 ^a	2.63±0.01 ^b	10.37±0.01 ^a	53.00±0.00 ^c
B	12.52±0.01 ^b	3.15±0.04 ^b	14.82±0.02 ^b	2.82±0.00 ^b	11.14±0.04 ^b	55.50±0.02 ^b
C	12.80±0.01 ^a	3.22±0.00 ^a	12.30±0.05 ^c	4.21±0.00 ^a	13.26±0.01 ^{bc}	57.05±0.01 ^a

Means in a column with the same superscripts are not significantly ($p < 0.05$) different from one another

Sample A= 60% wheat, 40% maize (Control);

Sample B= 70%wheat, 20% maize, 10% fermented *Parkia biglobosa*;

Sample C= 75% wheat, 10%maize, 15% fermented *Parkia biglobosa*

Sensory evaluation

The mean score values of the sensory attributes of the biscuits for crispness, appearance, aroma, taste and overall acceptability ranged between 5.30-6.40; 4.70-5.70; 4.70-5.90; 4.60-5.70; 4.82-5.87 respectively (Table 2). There were no significant ($p < 0.05$) differences in aroma, taste and overall acceptability of the biscuit samples. Sample C had the highest score for crispness, taste and overall acceptability. The enrichment of the biscuit with fermented *Parkia biglobosa* led to increase in the score values of taste, appearance, aroma and overall acceptability of the enriched biscuits. Overall acceptability mean score of the sample C was the highest (5.87) and most preferred followed by sample B (5.60) compared with sample A. This is contrary to the result of Adanse et al., (2020) where only 100% wheat biscuit was mostly preferred by the panelists for all the parameters.

Table 2: Sensory Attributes of the fermented *Pakia biglobosa* (locust beans) enriched wheat-maize composite flour biscuits

Samples	Crispness	Color	Aroma	Taste	Overall Acceptability
A	5.30±0.49 ^{de}	4.70±0.63 ^c	5.90±0.49 ^d	4.60±0.54 ^d	4.82±0.44 ^d
B	5.70±0.26 ^d	5.70±0.49 ^{bc}	5.80±0.41 ^c	5.5±0.37 ^{cd}	5.60±0.28 ^{cd}
C	6.40±0.22 ^{cd}	5.50±0.47 ^c	4.70±0.31 ^{bc}	5.70±0.30 ^{cd}	5.87±0.25 ^c

Means in a column with the same superscripts are not significantly different from one another ($p < 0.05$)

Sample A= 60% wheat, 40% maize (Control);

Sample B= 70%wheat, 20% maize, 10% fermented *Parkia biglobosa*;

Sample C= 75% wheat, 10%maize, 15% fermented *Parkia biglobosa*.

Conclusion

This study revealed that the sample C with 15% FPB had the desired lowest fat content, highest protein, fibre and carbohydrate contents. Also, sample C was the most preferred for crispness, taste and overall acceptability. Furthermore, the biscuits were richer in nutrients such as protein, ash, carbohydrate and fibre relative to control.

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NUTRITIONAL QUALITY OF ROASTED RED RICE - GERMINATED CHICK-PEA COMPOSITE FLOUR

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ABSTRACT

This study was carried out to evaluate the nutritional quality of roasted red rice - germinated chickpea composite flour. Red rice samples were roasted at 85 °C for 15 mins and chickpea samples were germinated for 24 and 48 hours after 12 hours soaking. Germinated chickpea flour and red rice flour was combined in the ratio 0.6 cup (91g) and 0.3 cup (43g). Ungerminated chickpea samples serve as control. Composite flour from roasted red rice and germinated chickpea and control were subjected to proximate analyses, functional properties and anti-nutritional factors using standard methods. The results showed that the moisture, fat and carbohydrates levels of germinated chickpea composite flour increased from 7.75-7.82%, 3.53-3.78% and 71.36-72.80% respectively, while the ash, protein and energy values decreased in the germinated flours from 2.23-2.12%, 15.25-13.67% and 378.57-377.97% respectively. After germination the anti-nutritional factors like, phytic acid, oxalic acid reduced from 26.2 – 25.6 g/100g and 14.21 – 13.72 mg/100g respectively. There was significant ($p \leq 0.05$) difference in anti-nutritional factors after germination and roasting. In conclusion, germination of legumes and roasting of cereal reduced the anti – nutritional factors and improved the nutrient availability of chickpea and red rice.

Key words: Nutrition, Quality, Red Rice, Germinated Chickpea, Composite Flour

INTRODUCTION

Legumes are the world's third most common flowering plant family (Sandoval et al., 2022). Soybean and peanuts are the most economically important legumes, and they are mostly utilised for oil production (Sandoval et al., 2022). Pulses, on the other hand, are a subclass of legumes that includes those whose seeds are used as food (Sandoval et al., 2022). Legumes are high in lysine and low in sulphur-containing amino acids, however they are balanced when mixed with grains (Sandoval et al., 2022). Legumes are high in resistant starch (RS) and have a low glycaemic index, despite their high carbohydrate content. Minerals make up to 3.5 percent of legumes, primarily phosphorus, calcium, magnesium, and potassium (Sandoval et al., 2022). Pulses are in higher demand as food ingredients because of the shift to more sustainable, nutritional, and ethnic foods (Sandoval et al., 2022). They can be used as meat substitutes or simply to boost protein content in cereal-based dishes (Sandoval et al., 2022). The trypsin inhibitory activity of legumes is reduced by traditional methods such as boiling, heating, germination, and fermentation (Sandoval et al., 2022).

Chickpea chemical components are high in micronutrients and bioactives while having a small environmental impact (Sarabi-Aghdam, et al., 2021). Chickpea flour is used in baking and has been shown to protect against a variety of heart ailments (Sarabi-Aghdam, et al., 2021). The nutritional value was comparable to soymilk, albeit with lower protein content (1–2 g/100 g) and a more pleasant taste (Sarabi-Aghdam, et al., 2021). Fermentation or germination can improve nutrition by decreasing antinutrients and releasing peptides, amino acids, and antioxidants (Sarabi-Aghdam, et al., 2021).

Chickpeas are a good source of fibre and can help you maintain a healthy blood sugar level. The glycaemic index of dry and canned chickpeas is low (Dass et al., 2014). This means they take a long time for your body to absorb and digest (Dass et al., 2014). They also include amylose, which is a slow-digesting kind of starch. These components work together to limit the blood sugar and insulin levels (Dass et al., 2014). They are digestive aids. They have the potential to reduce cancer risk in humans. When chickpeas are eaten, the body produces butyrate, a short-chain fatty acid. Butyrate has been shown in tests to aid in the removal of sick and dying cells in the body. This may reduce the chances of developing colorectal cancer. Other cancer-fighting chemicals found in chickpeas include lycopene and saponins (Dass et al., 2014).

According to the Indian indigenous medical system, red rice is a particular rice variety with medicinal effects on the circulatory, pulmonary, and digestive systems. It has a wide range of medical characteristics and is used to treat arthritis, cervical spondylitis, muscle atrophy, skin illnesses, and some neurological issues (Menon et al., 2014). Only dehulled rice is used, which preserves the medicinal qualities of the rice. Navara kizhi is an Ayurvedic treatment for paralysis, arthritis, and neurological disorders. A poultice is made by heating Navara rice in milk in this therapy (Menon et al., 2014). However, little scientific research on the nutritional and therapeutic qualities of Navara is known. Red rice has 16.5 percent more protein and greater levels of thiamine (27–32%), riboflavin (4–25%), and niacin (2–36%) when compared to two different kinds of rice varieties Navara rice and parboiled rice (Deepa et al., 2013).

The aim and objective of the study is to produce composite flour made from roasted red rice and germinated chickpea and to determine its nutritional qualities.

MATERIALS AND METHOD

Sample Collection

A quantity of 1kg Red rice (Navara) and desi variety chickpea was purchased from a super market in Navalur, Chennai, Tamil Nadu State, India.

Sample Preparation

In the preparation of flour, 300 g of desi variety chickpea and 200g of red rice (Navarra) were measured and washed thoroughly. This helps to remove contaminants and dust particles present in the chickpea and red rice. The red rice was sun dried while the chickpea was soaked in

the water for 12 hours preferably overnight at room temperature. The soaked chickpea was transferred to a clean cloth, tied and kept for germination. The germination times were 24 and 48 hours respectively. After the seeds have germinated the chickpea were kept under the sun for drying. The sun-dried red rice was roasted at 85 °C for 15 mins until the rice pops. Ungerminated chickpea was combined with the red rice and taken as a control sample. Germinated chickpea flour and red rice flour is combined in the ratio 0.6 cup (91g) and 0.3 cup (43g), (Chickpea: red rice) to create a complete protein profile. Control sample was also taken in the same ratio.

Proximate and anti-nutritional analysis

Proximate analysis of the composite flour samples was determined by using AOAC (2000) methods.

Anti-nutritional analysis (Tannic acid, oxalate and phytic acid) was determined using methods of AOAC, (2000) method.

Statistical Analysis

Data were analysed using SPSS Version 21.0 for windows (IBM Corporation, New York, USA). Variability within the means was separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$).

RESULTS AND DISCUSSION

The proximate composition of the composite flour

The proximate composition of the composite flour is present in Table 1. The moisture content of the flour for germinated chickpea and roasted red rice ranged from 7.75 – 7.82%. Ungerminated chickpea – roasted red rice flour had lowest moisture than germinated chickpea – red rice flour. Both the samples were not significantly different from each other. Germination of chickpea increased the level of moisture may be due to storage conditions. Low water content in the sample would enhance its storage stability.

The flour had protein values of 13.67-15.25%. Ungerminated chickpea - roasted red rice flour had the highest protein content while germinated chickpea – roasted red rice flour had the lowest. There was no significant difference between the two samples. Depending on the type of grain/seed, protein levels have been found to rise after germination (Otutu, et al., 2014). Serrano-Sandoval et al., 2022 reported that low amounts of protein for cakes and snacks.

The fat contents of the flour ranged from 3.53-3.78%. Germinated chickpea – roasted red rice flour had the highest fat content while ungerminated chickpea – roasted red rice flour had lowest. Soaking chickpea for 12 hours and germinating chickpea for 24 and 48 hrs increased the fat content. The predominant unsaturated fatty acids in chickpea are oleic and linoleic acid,

both of which increased significantly during the first three days after germination (Serrano-Sandoval et al., 2022).

The ash contents ranged from 2.12-2.23. Germinated chickpea – roasted red rice flour had highest value while ungerminated chickpea – roasted red rice flour had the lowest value of ash. There was no significant difference between two samples. Ash content is the residue remaining after all the moisture and organic materials have been removed (Serrano-Sandoval et al., 2022). The total carbohydrate content ranged from 69.12-71.44%. The highest was recorded in the germinated chickpea – roasted red rice sample and lowest in ungerminated chickpea – roasted red rice sample. The energy value of the sample ranged from 377.97-378.57 Kcal/100g. The energy value of ungerminated chickpea – roasted red rice flour was significantly higher than that of germinated chickpea and roasted red rice flour. Germination involves chemical changes due to the hydrolysis by the amylolytic enzymes alpha and beta amylases complex macromolecules like starch and proteins into low molecular weight and more digestible intermediate products (Deepa et al., 2008).

Table 1: Proximate Composition of Germinated chickpea and red rice flour and Ungerminated chickpea and red rice flour

Sample	Moisture %	Crude Protein %	Crude Fat %	Crude Fibre %	Ash %	Carbohydrate %	Total energy (kcal/100g)
Germinated chickpea and roasted red rice flour (Germinated for 24 h)	7.9±0.1 ^a	13.3±0.5 ^b	3.9±0.1 ^c	2.0±0.1 ^a	1.9±0.1 ^c	71.0±1.0 ^f	374.9
Germinated chickpea and roasted red rice flour (Germinated for 48 h)	7.9±0.1 ^a	12.9±0.5 ^b	4.0±0.1 ^c	1.9±0.1 ^a	1.9±0.1 ^c	71.4±1.0 ^f	372.3
Ungerminated chickpea and red rice flour	7.8±0.1 ^a	15.3±0.5 ^b	3.5±0.1 ^c	2.1±0.1 ^a	2.2±0.1 ^c	69.1±1.0 ^f	378.6

Analyses were done in triplicates to obtain mean values. Means were separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$). Mean $\pm$ standard deviation with same superscript along the column is not significantly different at ($p \leq 0.05$).

Anti-nutritional composition of composite flour

The tannic acid, phytic acid and oxalic acid content have been studied after 12 hrs of soaking, 24 and 48 hrs of germination time and roasting. Dehusking, germination, heating, and roasting have all been found to improve the nutritional quality of legumes and cereals. With germination, the amount of anti-nutritional components such as trypsin inhibitory activity, phytates, tannins, oxalates and total polyphenols decreased dramatically (Rao et al., 2018). Roasting was

found to be the most efficient method for decreasing phytic acid in dry seeds. Total polyphenols and tannins were all reduced by boiling pressure cooking (Rao et al., 2018). However, germination was more successful than the various cooking procedures in lowering trypsin inhibitor activity, tannins, polyphenols, and phytic acid (Rao et al., 2018).

Table 2: Anti-nutritional Composition of Germinated chickpea and red rice flour and Ungerminated chickpea and red rice flour

Sample	Tannic acid ($\mu\text{g}/100\text{g}$)	Phytic acid ($\mu\text{g}/100\text{g}$)	Oxalic acid ($\mu\text{g}/100\text{g}$)
Germinated chickpea and roasted red rice flour (Germinated for 24 h)	312 $\pm$ 5.0 ^a	20.6 $\pm$ 0.5 ^b	10.7 $\pm$ 0.1 ^c
Germinated chickpea and roasted red rice flour (Germinated for 48 h)	238 $\pm$ 4.0 ^a	14.6 $\pm$ 0.5 ^b	7.7 $\pm$ 0.1 ^c
Ungerminated chickpea and red rice flour	380 $\pm$ 5.0 ^a	26.2 $\pm$ 0.5 ^b	14.2 $\pm$ 0.1 ^c

Analyses were done in triplicates to obtain mean values. Means were separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$). Mean $\pm$ standard deviation with same superscript along the column is not significantly different at ($p \leq 0.05$).

In table 2 the results showed that ungerminated chickpea – roasted red rice flour had tannic acid content of 380 $\mu\text{g}/100\text{g}$. After germination the tannic acid content of the germinated chickpea – red rice flour reduced to 356 $\mu\text{g}/100\text{g}$, 312 $\mu\text{g}/100\text{g}$ and 238 $\mu\text{g}/100\text{g}$ for 12 hours, 24 hours and 48 hours respectively.

Ungerminated chickpea – red rice flour had phytic acid and oxalic acid content 26.2 $\mu\text{g}/100\text{g}$ and 14.2 $\mu\text{g}/100\text{g}$ respectively. The phytic acid and oxalic acid content reduced after germination of chickpea and roasting of red rice to 25.6 $\mu\text{g}/100\text{g}$, 20.6 $\mu\text{g}/100\text{g}$ and 14.6 $\mu\text{g}/100\text{g}$ for 12 hours, 24 hours and 48 hours respectively while oxalic acid contents were 13.7 $\mu\text{g}/100\text{g}$, 10.7 $\mu\text{g}/100\text{g}$ and 7.7 $\mu\text{g}/100\text{g}$ for 12 hours, 24 hours and 48 hours respectively. The findings of this study showed that germination and roasted reduced the amounts of anti-nutritional factors in chickpea.

CONCLUSION

The study concluded that roasting and germination affected the nutritional composition of red rice and chickpea composite flour. When comparing germinated chickpea – roasted red rice flour to ungerminated chickpea – red rice composite flour, germination increased moisture and decreased protein content. After germination, the anti-nutritional factors like tannic acid, phytic acid and oxalic acid reduced after the germination. From this study, it is believed that

germinated chickpea – roasted red rice flour could offer a wide range of nutritional properties that can be harnessed through processing to meet nutritional requirements and employed in the creation of a variety of foods.

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NUTRITIONAL QUALITY ATTRIBUTES OF COOKIES PRODUCED FROM COMPOSITE FLOURS OF REFINED WHEAT FLOUR, ALMOND AND FLAX-SEED

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ABSTRACT

This study was done to prepare cookies from composite flour made from refined wheat, almond and flaxseed flours. Cookies were produced with partial replacement of refined wheat flour (RWF) with almond flour (AF) and flaxseed flour (FS) at 100%, 90%, 80%, 70% and 60% with AF and FS in same ratio. The cookies were prepared using the standard technique by creaming the fat and sugar and then adding the dry ingredients (composite flour blends, milk powder, and baking powder). The dough formed was baked into cookies, and evaluated for nutritional and sensory qualities. The results showed a decrease in moisture level and an increase in protein, carbohydrate, and fat content in the cookie samples. Cookies prepared with the incorporation of 10% AF and 10% FS had higher acceptability in terms of sensory evaluation.

Key words: Nutrition, Cookies, Refined wheat flour, Almond, Flaxseed

INTRODUCTION

In India, the bakery business is one of the fastest growing sub-sectors of the economy. The Nielsen study showed that India is the world's leading market for biscuits, ahead of the US, Mexico, China, Argentina, France, Italy, Germany, Turkey, and Spain. While India showed a volume market share of 22%, the second slot was occupied by the US at 13%. The top three countries - India, US and Mexico - contributed over 40% of the total biscuits 10 largest markets in terms of volumes sales (The Economic Times, 2011). Cookies are soft, sweet baked delicacies that are often made with flour, sugar, and fat shortening or butter. Other ingredients like raisins, chocolate chips, and nuts can be added. Crisp cookies are known as biscuits in most English-speaking nations, with the exception of the United States and Canada (Adeyeye et al., 2016). Cookies have less moisture than other baked foods; therefore they are less prone to microbial deterioration and have a longer shelf life. They are ready-to-eat, convenient, and affordable food products that contain important digestive and dietary contents (Olaoye et al., 2006). However, refined wheat flour lacks certain essential amino acids such as tryptophan and lysine (Adeyeye et al., 2016). To boost the nutritional content of cookies, they are now made with composite flour or fortified with other rich sources of nutrients such as whey protein concentrate, wheat germ, oyster mushroom, cassava, and water chestnut flours (Adeyeye et al., 2016; Olaoye et al., 2006).

Almonds are nutrient-dense seeds. They are commonly used as snacks and as ingredients in a range of processed meals, including bakery and confectionery items (Arti Chauhan & Singh, 2016). The United States is the world's largest almond grower, followed by Spain and Australia (Kalita et al., 2018). Nut consumption has been shown to protect against a wide range of diseases, including obesity, hypertension, diabetes, and metabolic syndrome, in epidemiological studies and clinical trials (Kalita et al., 2018).

Flaxseed also known as linseed is gaining traction as a functional food in the global food system. As consumers' interest in foods with extraordinary health benefits grows, it has evolved as a functional food. India is the world's leading flaxseed producer in terms of acreage, accounting for 23.8 percent of the total, and third in terms of production, accounting for 10.2 percent of global production (Oomah 2001). The functional components in flaxseed that provide health benefits are α -linolenic acid (ALA), lignans, and dietary fiber.

Wheat flour, which is lacking in some amino acids like lysine and tryptophan, is commonly used to make cookies. They're made using fortified or composite flour to boost the nutritional content. Wheat (*Triticum aestivum* L.) is a major cereal crop for the majority of the world's population. Wheat is the world's most significant cereal crop, farmed in a wide range of climatic and environmental conditions. It offers about 55% carbs and 20% food calories consumed globally, according to global nutritional statistics (Guyih et al., 2020).

Composite flour is a blend of diverse flours from cereals, legumes, and root crops that has been designed to meet certain functional and nutrient requirements (Ubbor and Akobundu, 2009). Numerous studies have been done by incorporating almond seed and carrot flour blends (Guyih et al., 2020), sorghum flour (Sureda et al., 2020), watermelon seed, cassava (Ubbor and Akobundu, 2009).

This study was carried out to prepare and determine the nutritional qualities of cookies produced from a composite flour of refined wheat flour, almond and flaxseed.

MATERIALS AND METHODS

MATERIALS

Refined wheat flour, almond and flax seeds along with other ingredients that were used in cookie production like fat shortening, sugar, chocolate chips, vanilla essence, baking powder, and milk powder were purchased from the local market in Parrys, Chennai, India. These were stored at room temperature until used.

FORMULATION OF COMPOSITE FLOUR

Cookies were prepared with partial replacement of refined wheat flour (RWF) with almond flour (AF), and flax seeds flour (FS). To prepare the composite flour almonds, and flax seeds were slightly roasted and made into powders separately. The refined wheat flour purchased from the market and the prepared almond and flaxseed fours were mixed in five different

formulations of refined wheat flour (RWF) with almond flour (AF) and flaxseed flour (FS) at 100%, 90%, 80%, 70% and 60% with AF and FS in same ratio. Cookies were prepared from each separate formulation.

PREPARATION OF COOKIES

The cookies were prepared with the composite flour samples FS1, FS2, FS3, FS4 and FS5. The fat shortening is first creamed until it becomes soft and fluffy, along with sugar, salt, and ammonium bicarbonate solution. The dry ingredients, i.e almond flour, refined wheat flour, and flaxseed flour, milk powder, and baking powder were gradually added along with the fat and the dough was kneaded well. Vanilla essence and chocolate chips were added to enhance the taste. These were made into desired shapes and sizes and baked at 150°C - 160°C for 20 mins.

Proximate Analysis

Proximate analysis of the cookie samples CS1, CS2, CS3, CS4 and CS5 was determined by using AOAC (2000) methods.

Sensory Analysis

The sensory qualities of the cookies were conducted by five-member panelists. The panelists consisted of academic staff from the Department of Food Technology, Hindustan Institute of Technology and Science, Padur, Chennai, India. The samples were given to the panelists to rate each cookie based on the following parameters, color, texture, mouth-feel, appearance, taste and overall acceptability of the cookies using a 9 point hedonic scale with 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely.

Statistical Analysis

Data were analyzed using SPSS Version 21.0 for Windows (IBM Corporation, New York, USA). Variability within the means was separated by Duncan's multiple range test (DMRT) and significances were accepted at a 5% confidence level ($p \leq 0.05$).

RESULTS AND DISCUSSION

The results of the proximate analysis of the cookie samples are given in Table 1. Moisture content is one of the important parameters which influences the storage and shelf life of the product. The moisture content of the cookie samples ranged between 1.69- 3.73 which was within the required limit for cookie products. There was no significant decrease in moisture content of the cookies when compared with the flour sample values CS5 (Cookie sample 5) made with 60% refined wheat flour, 20% almond flour, and 20% flaxseed flour had a higher moisture content of 3.73 when compared with other samples.

The crude protein content of the cookie samples ranged from 7.64 to 9.10%. The crude protein content of CS1, CS2, CS3, CS4 and CS5 is 8.2%, 9.1%, 8.33%, 7.64%, and 8.32% respectively. The formulation of sample 2 cookies has higher protein content. The high crude protein content is desirable as cookies made from wheat flour are not good sources of dietary protein (Adeyeye et al., 2016). Almond has crude protein content of 21% protein which makes it a good source of protein. The crude fat content of the cookie samples ranged from 10.52 to 11.41. This may be due to the addition of 60% fat shortening during cookie preparation. As the substitution of almond and flaxseed increased, there was a gradual increase in the fat content noticed in the flour samples. FS1 with 100% refined wheat flour had the least value of 0.8%, and FS5 with 20% almond flour and 20% flaxseed flour showed a value of 0.92%. This trend may be observed due to the increase in content of unsaturated fatty acids in flax seeds and almonds. The crude fat content of almond is 50% fat which makes the crop a good source of fat and calories (Adeyeye et al., 2016). Almonds are a good source of the monounsaturated fat, oleic acid, and the polyunsaturated fat, linoleic acid, which could be beneficial for human nutrition.

The crude fibre content of the cookie samples ranged from 1.89 to 2.52%. The crude fibre content value increased after the preparation of cookies (Adeyeye et al., 2016). This shows the increase in crude fibre content as the formulation of almond and flaxseed increases. Flax seeds serve as a good source of both soluble and insoluble dietary fibre. Dietary fiber delays gastric emptying, regulates postprandial blood glucose levels and helpful in prevention of constipation. Dietary fibre increases the weight and size of stool and softens it. A bulky stool is easier to pass, decreasing the chance of constipation. Dietary fibre also helps to solidify the stool because it absorbs water and adds bulk to stool. It helps maintain bowel health (Guyih et al., 2020). The ash content of the cookie samples ranged from 0.53 to 1.52%, showing a gradual increase in value. There was no significant difference between the ash content of the cookie samples. The ash content helps determine the amount and type of minerals in food; it is important because the amount of minerals can determine physiochemical properties of foods, as well as retard the growth of microorganisms (Guyih et al., 2020).

The carbohydrate contents of the cookie samples showed a slow rise in values. In the cookie samples, the carbohydrate values ranged from 76.97 % to 78.17%. There was no significant difference when compared the cookie samples. Total energy of flour samples ranged from 354.86 kcal/100g to 367.76 kcal/100g and for cookie samples the values ranged between 437.42 kcal/100g to 445.93kcal/100g.

Table 1: Proximate analysis of the cookie Samples

Sample	Moisture %	Crude Protein %	Crude Fat %	Crude Fibre (on dry basis) %	Ash %	Carbohydrate %	Total energy (kcal/100g)
CS1	2.69±0.05 ^a	8.20±0.30 ^a	11.32±0.50 ^a	2.21±0.05 ^a	0.82±0.00 ^a	76.97±1.10 ^a	443.56
CS2	2.19±0.05 ^a	9.10±0.30 ^a	10.52±0.50 ^a	2.52±0.05 ^a	0.94±0.00 ^a	77.25±1.15 ^b	440.08
CS3	1.69±0.01 ^b	8.33±0.30 ^a	10.69±0.50 ^a	2.43±0.05 ^a	1.52±0.01 ^b	77.77±1.15 ^b	440.61
CS4	1.69±0.01 ^b	7.64±0.20 ^b	11.41±0.50 ^a	1.89±0.01 ^b	1.09±0.01 ^b	78.17±1.15 ^b	445.93
CS5	3.73±0.05 ^a	8.32±0.30 ^a	10.89±0.50 ^a	2.12±0.05 ^a	0.53±0.00 ^a	76.53±1.10 ^a	437.41

Analyses were done in triplicates to obtain mean values. Means were separated by Duncan's multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$). Mean $\pm$ standard deviation with same superscript along the row is not significantly different at ($p \leq 0.05$).

The average hedonic score given to the cookies by the sensory panel members are shown in Figure 1. Sensory evaluation results indicated that there were significant differences in the taste, consistency, and overall acceptability among the samples with respect to the supplementation levels. Cookie Sample 3 (CS3) had higher hedonic scores as compared to other samples. The taste and mouth-feel of CS2, CS3 and CS4 were almost similar, but the overall acceptability, appearance and texture of CS3 were higher. CS5 had the least hedonic score in taste, mouth-feel, and overall acceptability of the cookies. The results of sensory evaluation are according to the findings in Adeyeye et al., (2016), which reported that increasing the level of soy protein isolate, in the cookies resulted in the significant decrease in the sensory attributes of the cookies. This shows CS3 which was made by incorporating 10% of almond flour and 10% of flaxseed flour in 80% of refined wheat flour was tastier and more acceptable whereas the CS5 made with substitution of 20% almond flour and 20% flaxseed flour was least acceptable to the consumers.

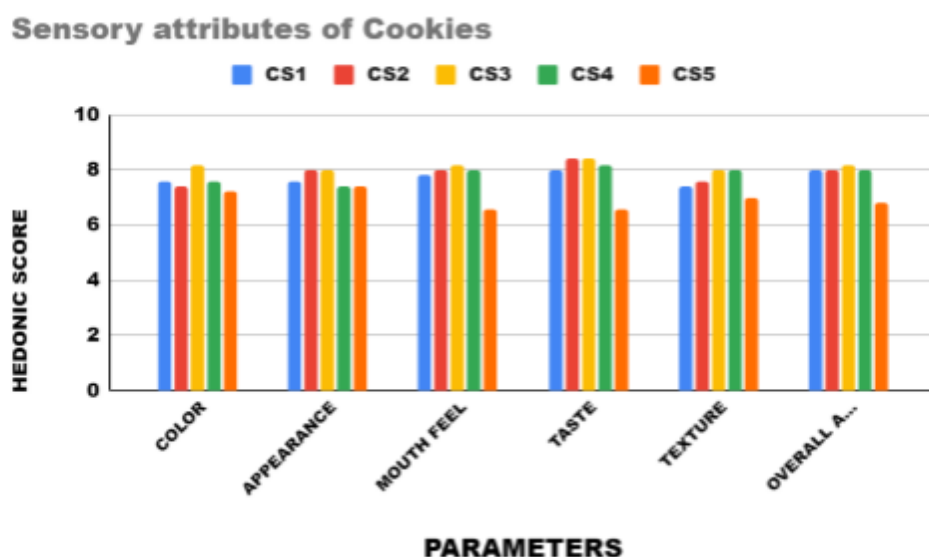


Figure 1: Sensory attributes of cookies from composite flour from refined wheat flour, almond flour and flaxseed flour

CONCLUSION

The present study was done to improve the nutritional quality of the cookies by incorporating almonds and flaxseed in different formulations as they are considered as a functional food globally. The incorporation of almonds and flaxseeds in cookies significantly affected the sensory and proximate qualities of the cookies. The cookies produced with the substitution of almonds and flax seeds at 10% had higher acceptance range and good proximate profile when compared with the other samples. Though the cookies prepared from the incorporation of 20% almonds and 20% flaxseed had higher nutrient value, these cookies do not have high acceptance in terms of taste.

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CHEMICAL COMPOSITION OF BISCUITS SUPPLEMENTED WITH INDIGENOUS VEGETABLE POWDERS

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Abstract

Indigenous vegetables are good sources of vitamins, minerals, dietary fiber and phytochemicals however they are being under-exploited. Biscuits are produced from wheat flour which is not a good source of micronutrients. This study was aimed at determining the effect of 10% addition of indigenous vegetables such as scent leaf (*Ocimum gratissimum*), curry leaf (*Muraya koenigii*) and *uziza* leaf (*Piper guineense*) on the nutrient composition of biscuits compared to the control (biscuit from 100% wheat flour). Proximate and mineral (calcium, magnesium, potassium, phosphorus, sodium, iron and zinc) composition of the biscuit samples were evaluated using standard methods. The crude protein and crude fibre content of biscuits substituted with scent leaf was significantly ($p>0.05$) higher than the other samples followed by biscuits substituted with curry leaves. Minerals such as calcium, magnesium, phosphorus and potassium content of biscuit substituted with *uziza* leaves were significantly higher than the other samples while sodium, iron and zinc contents were highest in biscuits substituted with curry leaf. The study showed that inclusion of the vegetables in biscuit improved their nutrient composition.

Keywords: Biscuit, *Uziza* leaf, Scent leaf, Curry leaf, Nutrient composition

Introduction

Micronutrient malnutrition is a major public health issue and has been estimated to affect as many as two billion people in the world (Luchuo *et al.*, 2013). The most common micronutrient deficiencies in children and childbearing women throughout the world include deficiencies of iron, iodine, zinc, and vitamin A. Vegetables play a significant role in human nutrition, especially as sources of vitamins, minerals, dietary fiber and phytochemicals (Dias and Ryder, 2011). They have been strongly associated with overall good health, improvement of gastrointestinal health and vision, reduced risk for some forms of cancer, heart disease, stroke, diabetes, anaemia, gastric ulcer, rheumatoid arthritis, and other chronic diseases (Keatinge *et al.*, 2010). Numerous leafy vegetables are readily available in Nigeria some of which include, scent leaf, *uziza* leaf, curry leaf etc. Despite the proven benefits of vegetables, they have been under-exploited in the development of food products. Biscuits which are ready-to-eat staple snack consumed by all age group in many countries are produced from wheat flour which is not a good source of micronutrients (Kumar *et al.*, 2011), hence the need to improve the nutritional value of biscuits. The main objective of this study was to evaluate biscuit fortified with vegetables such as scent leaf, curry leaf, and *uziza* leaves. The findings of this study will encourage the diversified utilization of curry leaf, scent leaf, and *uziza* leaf which will contribute in reduction of micronutrient malnutrition and in turn contribute to ensuring food security.

Materials and Methods

Wheat flour, *uziza*, curry and scent leaves used for this study were procured from Ubani main market, Umuahia, Abia State, Nigeria. Chemicals used were of analytical grade. The indigenous leaves were separately sorted to remove rotten leaves and thereafter washed in clean cold tap water and drained-off. The washed leaves were allowed to properly drip-off water and dried in the oven (at 50 °C for 5 h) and separately milled using a blender ? (indicate the model and place of manufacture) to obtain vegetable powders. Wheat flour was substituted with 10% of each of the vegetable powders and uniformly blended. The 100% wheat flour served as control. Functional properties of the flour blends such as bulk density, water absorption capacity, wettability and swelling capacity were determined according to the method described by Onwuka, (2018). Biscuits were produced with the following ingredients: flour(200g), margarine (50g), sugar (60g), Egg (25ml), salt (1.5g), flavour (2.5g), baking powder (3g) and water (30ml) using the rubbing-in-method (Reference?). The proximate composition, carbohydrate (by difference) and energy value (using Atwater factor) of biscuit samples were calculated according to the method of AOAC (2010). The mineral composition (phosphorus, calcium, magnesium, potassium, zinc, iron and sodium) of samples were determined following a standard method (Onwuka, 2018).

Results and Discussion

Proximate composition of biscuits

Significant differences ($p \leq 0.05$) exist on the moisture content of the various biscuit samples with the control having the highest moisture content (8.44 %) while 90%Wheat and 10% *uziza* leaf biscuit had the lowest (7.66 %). High moisture in biscuits is undesirable as it can enhance the growth of spoilage organisms. The moisture content of the samples were <10% which is the recommended limit for safe keeping. Inclusion of scent leaf and curry leaf powders significantly increased the crude protein content of the biscuit samples while there was no significant difference between the crude protein content of the control and the biscuit containing *uziza* leaf powder. Inclusion of the indigenous vegetable powders significantly ($p \leq 0.05$) increased the crude fiber content of the biscuit samples with 90%Wheat and 10% Scent leaf biscuit having the highest fiber content (2.91 %). Fiber has been reported to aid digestion, absorption of water from the body, bulk stool and prevent constipation (Idris *et al.*, 2011). Ash content (an indication of the mineral content of a product) was significantly higher in biscuit samples with vegetables than the control with samples substituted with *uziza* leaf having the highest. The fat, carbohydrate content and energy value of the biscuit samples significantly reduced with inclusion of the vegetable powders.

Table 1: Proximate composition of the biscuit samples supplemented with vegetable powders

Parameters	100% wheat flour (control)	90%wheat:10 % Curry leaf	90% wheat:10% <i>Uziza</i> leaf	90%wheat: 10% scent leaf
Moisture (%)	8.44 ^a ±0.07	8.20 ^b ±0.04	8.15 ^b ±0.06	7.66 ^c ±0.05
Crude protein (%)	10.63 ^c ±0.02	10.90 ^b ±0.03	10.58 ^c ±0.02	10.98 ^a ±0.01
Crude fiber (%)	1.33 ^d ±0.04	2.35 ^b ±0.03	2.24 ^c ±0.03	2.91 ^a ±0.03
Ash (%)	1.86 ^c ±0.04	2.05 ^b ±0.01	2.64 ^a ±0.04	2.12 ^b ±0.02
Fat (%)	12.79 ^a ±0.01	12.58 ^b ±0.02	12.61 ^b ±0.06	12.67 ^b ±0.02
CHO (%)	65.49 ^a ±0.07	63.34 ^d ±0.01	64.38 ^b ±0.04	63.70 ^c ±0.10
Energy (Kcal)	419.57 ^a ±0.49	410.12 ^c ±0.33	413.31 ^b ±0.25	412.48 ^b ±0.33

Values are mean ± standard deviation of triplicate determinations. Means with different superscripts within the same row are significantly different (p<0.05)

Mineral composition of the biscuit samples

The calcium content of the biscuit sample substituted with *uziza* leaves was significantly higher (58.66mg/100g) than the other samples. This implies that 100 g of biscuit substituted with *uziza* leaves can provide up to 5 % of the recommended calcium intake (RNI) which is 600 mg a day for children and 1000 mg a day for an adult (FAO, 2007). The magnesium, phosphorus and potassium content of biscuit substituted with *uziza* leaves were also significantly higher than the other samples; however its sodium, iron and zinc contents were the lowest. This conforms to the report of Idris *et al.* (2011) who stated that *uziza* has high mineral content such as calcium, magnesium, copper and potassium. Magnesium is important in Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) synthesis while phosphorus is required for maintaining body functions, production of energy and works alongside calcium to maintain healthy teeth and bones (FAB, 2016). Iron which is essential in the formation of red blood cells and in the transport of oxygen (James *et al.*, 2015) was highest (2.36mg/100g) in biscuit substituted with curry leaf powder.

Table 2: Mineral composition of the biscuits supplemented with vegetable powders

Minerals	100% wheat flour (control)	90% wheat flour 10% Curry leaf	90% wheat:10% <i>Uziza</i>	90%wheat flour: 10% Scent leaf
Calcium (mg/100g)	30.12 ^b ±0.02	28.76 ^d ±0.02	58.66 ^a ±0.03	29.75 ^c ±0.01
Magnesium (mg/100g)	45.22 ^b ±0.03	40.57 ^d ±0.01	56.82 ^a ±0.02	41.33 ^c ±0.02
Phosphorus (mg/100g)	3.36 ^c ±0.02	3.24 ^d ±0.01	20.74 ^a ±0.02	4.81 ^b ±0.01
Potassium (mg/100g)	60.72 ^b ±0.01	51.28 ^d ±0.03	69.47 ^a ±0.02	56.27 ^c ±0.02
Sodium (mg/100g)	3.10 ^d ±0.01	6.20 ^a ±0.01	3.40 ^c ±0.03	5.62 ^b ±0.01
Iron (mg/100g)	1.60 ^d ±0.00	2.36 ^a ±0.01	1.74 ^c ±0.01	1.84 ^b ±0.02
Zinc (mg/100g)	2.56 ^c ±0.02	9.41 ^a ±0.01	1.85 ^d ±0.03	4.30 ^b ±0.02

Values are mean $\pm$ standard deviation of triplicates or duplicates. Means with different superscripts within the same row are significantly different ($p < 0.05$)

Conclusion

The result of this study has revealed that addition of *uziza*, curry and scent leaves flours in biscuit production increased the nutrient composition of the biscuits. Biscuits containing scent leaf and curry leaf powder had the highest protein and fiber contents while mineral such as calcium, magnesium, phosphorus and potassium content were significantly higher in biscuits containing *uziza* leaf powder.

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VITAMIN AND SENSORY EVALUATION OF MAIZE 'MASA' ENRICHED WITH SOYBEANS AND DRIED CATFISH FLOUR

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Abstract

Masa is a traditional fermented fried food which is round in shape with brown smooth body made from cereal. This study was carried to evaluate vitamin and sensory properties of maize-masa, enriched with soybean and dried catfish flour. The enriched maize-masa produced were labeled sample A (100% maize), sample B (maize: soybean: catfish 70:20:10% proportion respectively) sample C (maize: soybean: catfish 70:10:20% proportion respectively) sample D (maize: soybean: catfish 80:10:10% proportion respectively) sample E (maize: soybean: catfish 70:15:15% proportion respectively). The result for vitamin A content of the five samples ranged from 0.43-0.99 mg/g with highest in sample B and lowest in sample A. The result for sensory quality attributes showed significance difference ($p < 0.05$) in all the attributes of the enriched maize-masa, however Sample A which is the 100% maize is the most acceptable by the panelist and also enrichment of masa with soybeans and catfish considerably improved the vitamin content.

Key words: Masa; Vitamin; Sensory Evaluation,

Introduction

Masa is a common food in the Northern part of Nigeria, it is a food from cereal but studies have shown that most of these cereals are low in protein. Therefore, Masa is among the common foods that is low in protein, this demands effort to uplift its nutritional qualities.

Masa can be produced from maize (*Zea mays*), millet (*Pennisetum typhoides*), sorghum (*Sorghum vulgare*) and rice (*Oryza sativa*) (Sanni and Adesulu, 2013). It is consumed in various forms by groups and tribes mostly in the Northern Nigeria and many other African countries (Mail, Burkina Faso, Niger, Chad and Ghana). Masa serves as snacks or as a breakfast meal cake for many (Nkama et al., 2003).

Soybean (*Glycine max*) is a leguminous vegetable of the pea family that grows in tropical, sub-tropical, and temperate climates. Soybean consists of more than 36% protein, 30% carbohydrates, and excellent amounts of dietary fiber, vitamins, and minerals. It also consists of 20% oil, which makes it the most important crop for producing edible oil (Edema et al., 2005).

African catfish (*Clarias gariepinus*) of the family Clariidae, is a moderately fatty fish that is also a good source of high-quality fish protein that occur in high concentration and possess an

excellent amino acid balance(Eyo, 2001).Maize, soybeans and Catfish combination was used by this study is to uplift the vitamin properties of maize-Masa.

Materials and method

Preparation of masa

Masa was produced using the modified method of Malomo and Abiose (2019). The maize was cleaned to remove unwanted particle, then rinsed with clean water. After which it was sun dried to reduce the moisture content of the maize. The dried maize was then dehulled using dehuller machine to remove the husk, and then dry milled using milling machine. It was then sieved into grits and flour to obtain maize flour.

Soybean seeds were cleaned by removing unwanted particles, and then soaked in clean water for 5 hours. Testa was removed by rubbing in-between the palms and washed several times with more water. The washed beans were then sun dry. The dried bean was roasted in an oven for 15 minutes, to reduce the anti-nutritional content then milled to make soybean flour.

The catfish on the hand was washed, salted which help to draw moisture from the fish, it was then placed on a wire rack with pan underneath to catch the drip, and oven dried at 150°C for 2hours, and allowed to cool. The dried fish was then milled into powder.

The Maize, soybean and catfish flours were proportioned in the following ratios as:100:00:00Sample A,70:10:20sample B,70:20:10sample C,80:10:10sample D,and 70:15:15sample E.Warm water (appreciable volume to form slurry), 30g of sugar and 5g of yeast were added to each sample and were thoroughly mixed and allowed to ferment for about 5 hours, after then, a pinch of salt was added to the mixture for taste and then mixed to obtained smooth batter, the batter was then fried in hot vegetable oil. It was then allowed to cool.

Determination of Vitamins

The method described by Okwu and Okwu(2004) was employed for determination of vitamin A and C.

Sensory evaluation

The sensory evaluation of the samples was carried out for consumer acceptance and preference using 20 panelists who were selected from among students and staff of the Department of Food Science and Technology, Federal University Dutsinma, Katsina State Nigeria. The quantities evaluated was rated on Hedonic scale ranging from one to nine (1 to 9) where; 9—Like extremely; 8—Like very much; 7—like moderately; 6—Like slightly; 5—Neither like nor dislike; 4—Dislike slightly; 3—Dislike moderately; 2—Dislike very much; 1—Dislike extremely. The mean scores were differentiated using one way analysis of variance. The qualities assessed include colour, taste, odour, texture, appearance and general acceptance.

Statistical analysis

The analysis of variance (ANOVA) was used to analyze all data using the statistical package for statistical package for social sciences (SPSS) version 16 for windows. Mean separation was performed by the LSD test ($p \leq 0.05$)

Result and Discussion

Table 1 shows the vitamin result, vitamin A content of the five samples ranged from 0.43-0.99 mg/100g with highest in sample B and lowest in sample A. This is also similar to what Samuel *et al.*, (2015) reported.

Table 1: Vitamin composition of maize masa enriched with soybeans and dried catfish flour

Samples	Vitamin A (mg/100g)	Vitamin C (mg/100g)
A	0.43±0.04 ^c	0.57±1.83 ^c
B	0.99±0.00 ^a	3.45±565.68 ^{ab}
C	0.97±0.03 ^a	3.89±0.28 ^a
D	0.70±0.28 ^b	3.01±14.17 ^b
E	0.98±0.14 ^a	3.16±141.45 ^b

Values are means $\pm$ standard deviation of triplicate determination; Means with different superscript in the same column are significantly different at $p < 0.05$.

KEY: Sample A= 100% maize masa; Sample B=70% maize, 10% catfish, 20% soybeans masa; Sample C= 70% maize, 20% catfish, 10% soybean masa; Sample D= 80% maize, 10% catfish, 10% soybean masa; Sample E= 70% maize, 15% catfish, 15% soybean masa.

Vitamin C content of the five sample ranged from 0.57-3.88 mg/100g with highest in sample C and lowest in sample A. Significant ($p < 0.05$) difference was observed in sample A and sample B however, sample B, C, D, E are not significantly difference. The value for vitamin C content increased greatly with the addition of soybean and catfish.

Table2: Sensory Evaluations of maize masa enriched with soybeans and dried catfish flour

Sample	Appearance	Aroma	Mouth feel	Taste	General Acceptability
A	7.75±0.72 ^a	6.95±1.57 ^a	6.45±1.79 ^a	6.50±1.82 ^a	6.95±1.54 ^a
B	6.65±1.53 ^b	5.50±1.79 ^{bc}	5.10±1.97 ^{bc}	4.50±1.54 ^b	5.35±1.60 ^{ab}
C	5.00±2.08 ^c	5.10±2.13 ^{bc}	4.85±2.08 ^c	4.85±2.28 ^b	4.85±1.87 ^{bc}
D	6.15±2.01 ^b	5.75±1.71 ^b	5.65±1.50 ^{bc}	5.35±1.76 ^{ab}	5.80±1.70 ^b
E	4.45±2.01 ^c	4.35±1.98 ^c	4.15±1.90 ^c	4.30±2.11 ^b	4.55±1.93 ^c

Values are means $\pm$ standard deviation of triplicate determination; Means with different superscript in the same column are significantly different at $p < 0.05$.

KEY: Sample A= 100% maize masa; Sample B=70% maize, 10% catfish, 20% soybeans masa; Sample C= 70% maize, 20% catfish, 10% soybean masa; Sample D= 80% maize, 10% catfish, 10% soybean masa; Sample E= 70% maize, 15% catfish, 15% soybean masa.

The mean result for colour of the samples ranged from 4.45-7.75 with sample A rated the highest followed by sample B, while sample E rated the lowest containing 15% soybean and 15% catfish. Significant ($p < 0.05$) difference was observed among all the samples. The result of general acceptability ranged from 4.55-6.95. There was significant difference ($p < 0.05$) in the general acceptability of the samples. But the general acceptability of sample A out of the five samples was the highest and most preferred. Sample E was the least preferred maybe due to the level of the proportioning. Samuel *et al.*, (2015) also reported similar result in the general acceptability.

Conclusion and recommendation

Sensory attribute were not really acceptable due to the fact that the panelist are new to the blends but the sensory characteristics were rated acceptable by the panelists, also enrichment of masa with soybeans and catfish considerably improved the vitamin content Therefore, it is recommended that vitamins B, D and E of masa be researched.

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EFFECT OF GERMINATION ON THE INVITRO-DIGESTIBILITY AND PASTING PROPERTIES OF COMPLEMENTARY FOOD FROM RICE, PIGEON PEA AND CARROT FLOUR BLENDS

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Abstract

The germination of cereal grains can be very useful in improving the invitro-digestibility and pasting properties of flours in new product development and their behaviour during preparation of complementary foods. Therefore, this study examined the effect of germination on the invitro-digestibility and pasting properties of complementary food from blends of rice, pigeon pea protein concentrate and carrot flour. Rice and carrot were processed according to standard methods. Pigeon pea was germinated at 25°C for 48h, dried before obtaining the pigeon pea protein concentrate flour. The resulting flours were formulated in the ratio of 60:10:30, 65:10:25 and 70:10:20 for rice, pigeon pea protein and respectively while commercial product serves as control. Protein and starch digestibility were estimated by in-vitro enzymatic digestion while pasting properties were determined using rapid visco-analyzer. The protein digestibility decreases as the concentration of the rice increases when it was digested for 1h which ranged from 75.53 to 85.665 and increased significantly when it was digested for 6h from 79.12 to 93.95. Likewise starch digestibility decreases as the concentration of the rice increases. Germinating the pigeon pea significantly increased the pasting properties. However, the blend with the lowest rice inclusion had the best in-vitro digestibility and better pasting properties.

Keywords: Complementary food, Blends, Germination, Invitro-digestibility, Pasting properties,

1.0 Introduction

Complementary foods play a dynamic role in infant growth and development because they supplement the infant's nutritional and developmental needs when breast milk alone is no longer sufficient (Temesgen, 2013). A good and sufficient complementary food should have a high nutrient density, low viscosity, bulk density, and appropriate texture, as well as a high energy, protein, and micronutrient content and a consistency that allows for easy consumption (Balasubramanian *et al.*, 2014). The recommended age for starting complementary feeding is 6 months; one reason for this is the physiologic delay in pancreatic α -amylase production and discharge in normal infants (Schiess *et al.*, 2010). Traditional complementary foods, which are typically made of cereals and or root crops, may be deficient in macronutrients as well as micronutrients such as protein, vitamin A, zinc, and iron. Furthermore, these cereal and root crop based complementary foods have high concentrations of fiber and anti-nutrients, which reduce the bioavailability of existing nutrients and are lower in nutrient density due to starch

gelatinization, which immediately fills the stomach of infants. To address these issues, various traditional food processing techniques are being used to create complementary food from locally available low-cost food items that are nutritious and acceptable.

Germination is a natural process that occurs during the growth period of seeds in which they meet the minimum growth and development requirements (Sagronis *et al.*, 2006). During this time, reserve materials, which are commonly used for respiration and synthesis of new cells prior to embryo development, are degraded (Vidal-valverde *et al.*, 2002). The process begins with the quiescent dry seed absorbing water and ends with the emergence of the embryonic axis, which is usually the radicle (Adebayo and Arinola, 2017). Several studies on the effect of germination on legumes reveal that it can increase protein content, dietary fiber, reduce tannin and phytic content, and increase mineral bio availability (Ghavidel and Prakash, 2006). Germination has also been linked to an increase in vitamin concentration and trace element and mineral bioavailability (Adebayo and Arinola, 2017). Germination improved calcium, copper, manganese, zinc, riboflavin, niacin, and ascorbic acid content, according to Kaushik *et al.* (2010). Hence the aim of this study was thus to determine the effect of germination on the invitro-digestibility and pasting properties of complementary food from blends of rice, pigeon pea protein concentrate and carrot flour.

2.0 Materials and Methods

2.1 Materials

Local rice, pigeon pea, carrots and commercial product were procured from Kure Ultra-Modern Market, Minna, Niger State.

2.2 Sample preparation

After cleaning, the dried rice was milled. The method described by Marvin (2009) was used in the preparation of carrot powder. Pigeon pea seeds were sorted, cleaned and was then soaked in clean water for 6h the water was changed every 2h intervals to avoid fermentation. After soaking, the grains were spread on jute bags and left to sprout for 48h with sprinkling of water at intervals. The germinated pigeon pea was dried using solar drier for 48h and then milled. The protein extraction was carried out using the method described by Chandi and Sogi (2007).

3.0 Results and Discussion

3.1 Protein and Starch Digestibility of the Blends

The protein digestibility of the blend (Table 1) decreases as rice concentration increases when digested for 1h, ranging from 75.53 to 85.665, and increases significantly when digested for 6h, ranging from 79.12 to 93.95. The starch digestibility of the blend decreases as the rice concentration increases, ranging from 70.05 to 80.25. The slow digestion characteristics are determined by the arrangements of starch components (amylose and amylopectin) in concentric rings with crystalline and amorphous areas, as well as their branching patterns. When amylolytic enzymes are applied to starch granules, the enzymes migrate through the channels within the starch granules, resulting in slower digestion due to inside out and side by side digestion (Zhang and Hamaker, 2009). Enzymatic digestion usually begins at the surface pores and interior channels; this side by side digestion gradually enlarges the channel by digesting both crystalline and amorphous regions at the same time (Miao *et al.*, 2015).

3.2 Pasting properties of the blends

The peak viscosity (PV) of the blends (Table 2) ranged from 134.465 to 177.355 RVU. Peak viscosity varies in relation to swelling power and disruption rate of starch granules (Rithesh *et al.*, 2018). A higher peak viscosity indicates a greater capacity for water binding and swelling power. During the cooking process, the control had the lowest break-down value (Thiranusornkij *et al.*, 2018). All of the formulated blends had higher peak viscosities than the control blend. Low peak viscosity of a diet implies that the complementary diet will form a low viscous paste rather than a thick gel on cooking and cooling (Otegbayo *et al.*, 2006). This means that the gruel will be a high caloric density per food unit volume rather than a dietary bulk (Arisa *et al.*, 2013). The trough measures the ability of the paste to withstand breakthrough during heating (Adebowale *et al.*, 2008). It is the minimum viscosity value in the cooking temperature phase of the RVA profile and ranged from 125.965 RVU to 165.355 RVU with the formulated blends having higher values which are significantly different from each other. The breakdown which is the difference between the peak viscosity and trough viscosity was also observed to have higher values in the formulated blends than the control with their values ranging from 9.11 RVU and 12.76 RVU. Breakdown values of the samples exhibit significant difference ($p < 0.05$). The breakdown viscosity value is an index of stability of starch (Fernandez and Berry, 1989). Breakdown viscosity decreases with increasing amylose content (Lin *et al.*, 2010). The higher the breakdown the lower the ability of the starch to withstand heat and shear stress during cooking (Adebowale *et al.*, 2005). This infers that the formulated blends are more stable to heat and mechanical shear (Oladele and Aina, 2007) compared to the sample D (control).

The final viscosity was observed to also have higher values which varied from 170.695RVU and 185.36 RVU and are significantly different ($P < 0.05$) from each other. The setback values are all significantly different ($p < 0.05$) from each other and the values are higher for all the formulated blends compared to the sample D (control) with values ranging from 20.35RVU and 45.335 RVU. The peak time is a measure of the cooking time. The result shows that the value of the peak time ranged from 6.45 minutes to 8.55 minutes and they all exhibited significant difference ($p < 0.05$) from each other. The pasting temperature flour blends varied between 65.75°C to 73.75°C and they are significantly different ($p < 0.05$) from each other. The pasting temperature is an indication of the minimum temperature required to cook the sample (Kim *et al.*, 1995). The attainment of the pasting temperature is essential in ensuring swelling, gelatinization and subsequent gel formation during processing. The pasting temperature is the temperature at which the viscosity starts to rise (Liang and King, 2003). From the result, the pasting temperature of the formulated blends and the control were of closed range (65.75⁰ C to 73.75⁰ C) which indicates that all he blends have low gelatinization temperatures and hence a shorter cooking time.

Table 1. Protein and Starch digestibility of the formulated blends

Samples	Protein Digestibility		Starch Digestibility (%)
	Digestibility at 1h (%)	Digestibility at 6h (%)	
A	85.67 ^a ±0.01	93.95 ^a ±0.01	80.25 ^a ±0.01
B	80.16 ^b ±0.01	86.45 ^b ±0.01	78.37 ^b ±0.01
C	75.43 ^c ±0.01	79.125 ^c ±0.01	76.83 ^c ±0.01
D	70.53 ^d ±0.02	76.215 ^d ±0.01	70.05 ^d ±0.00

Values are means ± standard deviation of triplicate determination. Values in the same column with different superscripts are significantly different (p≤0.05).

Keys: Sample A: 60% of Rice, 10% of pigeon pea and 30% of Carrot flour
 Sample B: 65% of Rice, 10% of Pigeon pea and 25% of Carrot flour
 Sample C: 70% of Rice, 10% of Pigeon pea and 20% of Carrot flour
 Sample D: Control (Commercial Product)

Table 2. Pasting properties of the blends

Samples	Peak Viscosity (RVU)	Final viscosity (RVU)	Setback (RVU)	Breakdown (RVU)	Pasting time (Min)	Pasting Temperature (° C)	Trough (RVU)
A	177.36 ^a ±0.00	185.36 ^a ±0.01	20.35 ^a ±0.00	12.76 ^a ±0.01	8.55 ^a ±0.00	65.75 ^a ±0.00	165.355 ^a ±0.01
B	171.23 ^b ±0.01	188.11 ^b ±0.01	28.76 ^a ±0.04	11.63 ^b ±0.01	8.00 ^b ±0.00	68.16 ^a ±0.01	160.230 ^b ±0.01
C	168.00 ^c ±0.01	199.04 ^a ±0.00	40.16 ^b ±0.01	10.76 ^c ±0.01	7.62 ^c ±0.00	69.15 ^b ±0.00	158.155 ^c ±0.00
D	134.46 ^a ±0.01	170.69 ^a ±0.02	45.34 ^a ±0.01	9.11 ^a ±0.01	6.45 ^a ±0.00	73.75 ^a ±0.00	125.960 ^a ±0.01

Values are means ± standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different (p ≤0.05).

Keys: Sample A: 60% of Rice, 10% of pigeon pea and 30% of Carrot flour
 Sample B: 65% of Rice, 10% of Pigeon pea and 25% of Carrot flour
 Sample C: 70% of Rice, 10% of Pigeon pea and 20% of Carrot flour
 Sample D: Control (Commercial Product)

4.0 Conclusion

There was a positive effect of germination on the formulated complementary food because tests on its digestibility revealed that it can be easily digested. It also demonstrated excellent pasting qualities.

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PROXIMATE COMPOSITION AND TECHNOLOGICAL PROPERTIES OF GLUTEN-FREE CAKE FROM BROWN RICE AND CORN FLOUR BLENDS

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Abstract

The demand for gluten-free foods including snacks are increasing recently due to high level of gluten intolerance among growing population of young children in the world. Hence, the need to produce gluten-free snacks such as cake from common gluten-free raw materials is important so that people with celiac disease will have access to gluten-free snack varieties. This study evaluated the chemical, physical, and sensory attributes of gluten-free cake from blends of brown rice and corn flour. Gluten-free cake was produced from varying proportions of brown rice (40 - 60%) and corn flour (20 - 40%), with 20% tapioca starch as binder. The chemical composition, physical composition, and sensory attributes of the cakes were determined using standard analytical methods. The protein content of the cake increased slightly from 9.75 to 10.28%. The crude fibre were within the ranges of 1.17-1.30%. In terms of physical properties, the 55:20:25 gluten-free cake height (2.97 cm) and specific volume (2.44 cm³/g) was higher than that of the other cake samples which were within the ranges of 2.55 – 2.73 cm and 2.06 – 2.28 cm³/g for height and specific volume, respectively. In terms of sensory attributes, the 55:20:25 cake was highly rated in terms of taste, colour, aroma and overall acceptance.

Introduction

Cake is part of bakery product with distinct characteristics from other baked foods. It is a fluffy snack with either cream, chocolate, or strawberry colour, sweet taste, or attractive aroma. In general, the colour of cakes vary, depending on the ingredients and consumers choice. Cake is a commonly consumed snack in Nigeria. Its consumption is increasing recently in towns and cities due to the people's busy lifestyles. In Nigeria, people sometimes take cakes as dessert or take it together with drink as lunch.

The major raw materials for cake production are wheat flour, yeast, sugar, salt, and water (Patil & Pol, 2014). However, because some people are gluten intolerant, and because of high prices of wheat in non-wheat producing countries which are mostly tropical countries such as Nigeria, other non-wheat flour have been used to replace wheat flour for cake preparation. The nutritional profile and acceptability of gluten-free cakes produced from blends of brown rice, chickpeas and pumpkin seeds (Agarwal *et al.*, 2020), rice and flaxseed flour (Sung and Chai, 2017), cassava, pumpkin and potato flour (Ammar and Abd El-Razik, 2013), and sorghum flour, gelatinized corn flour, germinated rice flour, and rice flour (Hussein *et al.*, 2012) have been reported. This study aimed at evaluating the proximate composition and technological properties of gluten-free cake from blends of brown rice and corn flour.

Materials and methods

Brown rice(Mojray foods:38791) was purchased from a local supermarket in Ogbomoso (Beant mall), Cassava roots were purchased from Arada marketOgbomoso, Corn flour, baking powder, and salt were purchased from Maxwell cakes Ogbomoso, Nigeria. Others materials such as rolling pin, mixer(Kenwood Stand Mixer, HM430, China), weighing scale(Camry kitchen scale – 20kg, China), rolling board, locally fabricatedcabinet dryer and hammer mill , sieve, and oven (thermomate, China)and were obtained from the Food processing Laboratory, Food science and Engineering Department, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Preparation of brown rice flour from brown rice

The brown rice (500g) was washed using distilled water (1:3 w/v) and dried in the oven(50°C, 2h), milled using grain milling Machine (M6FFC), sieved to pass through 250µM sieve mesh size to obtain a smooth powder.

Preparation of tapioca starch

The tapioca grit was produced through traditional method described by Adebowale *et al.* (2006). The fresh cassava tubers (TME 419)were washed, peeled with a sharp knife and re-washed to remove dirt. The peeled cassava tubers were grated with a hand grater of finest teeth to ensure effective disintegration of the cassava tissue. The resultant pulp was mixed with water and sieved through a muslin cloth to separate the starch from the fibrous pulp and other coarse root materials. The starch pulp was allowed to settle for 4-6 h before decanting the water. The thick starch at the bottom of the bowl was pressed in muslin cloth to reduce the water content. The starch was sun dried for two days, disintegrated and sieved to obtain smooth starch flour.

Cake formulation and Preparation

Composite flours were prepared by mixing brown rice flour, tapioca starch and corn flour in the following proportions; 60:20:20, 55:20:25, 50:20:30, and 40:20:40, respectively. Cake samples were produced from all the composite flours and cake produced from 80:20 (brown rice flour: tapioca starch) serves as control. For the preparation, granulated sugar (100g) and margarine (140g) were mixed in a bowl to a creamy consistency by continue mixing to a point where the mixture is light and fluffy. Other ingredients such as the composite flours (200 g), baking powder (1.5g) and salt (1g) were mixedwith the margarine to a fine consistency batter. The batter was placed in creased pans, baked (190°C, 15min), allowed to cool (1 h) at room temperature and packaged until further analysis.

Determination of Proximate Composition ofthe Gluten-Free Cake

The crude protein, crude fat, crude fibre, ash, and moisture contents of the cake samples were determined according to AOAC(2010), while carbohydrate was determined by difference.

Physical analysis of the Gluten-Free Cake

Weight: The weight of the cakes was determined using a digital weighing balance. The cake samples were measured in (g) and an average value of four individual cake was recorded as the weight AACC (2000).

Volume: The cake volume was determined after cooling for 15 minutes. The volume was measured using the rapeseed displacement method. Each cake was put in a container and covered with rapeseed to totally fill the container. Then the cake was removed and the volume of the rapeseed was recorded according to AACC (2000).

Cake specific volume: Cake specific volume was calculated by the following formula after measuring cake volume and weight AACC (2000).

$$\text{Specific volume (cm}^3\text{/g)} = \frac{\text{Cake volume}}{\text{Cake weight}}$$

Cake height: The height of 4 cakes placed closely besides each other (edge-to-edge) was measured with a vernier caliper and the average height was recorded.

Sensory evaluation

Sensory evaluation was carried out using thirty semi-trained panelists. The samples were presented in a disposable cupcakes paper coded with combination of letters and figures, and the evaluation was done individually in a cubicle under illumination. The panelists were asked to score the cakes based on colour, aroma, appearance, taste and overall acceptability, using a 9-point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).

Statistical analysis

All analyses were carried out in triplicate. Data obtained in this study were subjected to analysis of variance (ANOVA). Differences among the samples means were separated using Duncan's multiple range test and significances were accepted at 5% level ($P \leq 0.05$).

Results and Discussion

Proximate composition of the gluten-free cakes

The proximate composition of the gluten-free cake is shown in Table 1. The cake sample produced from brown rice and tapioca starch only (sample E) had the highest protein content (10.28%) probably because of the presence of germ (which is part of the aleuron layer of the brown rice). The cake sample from the equal proportion of brown rice and corn flour (sample D) had the least protein contents (9.75%). This could be due to low protein (6.43 – 6.82%) in corn flour (Tene et al., 2019). The moisture contents (20.67 – 24.57%) of the gluten-free cake was close to the range of moisture contents (26.12 – 28.55%) reported for gluten-free cakes from sorghum flour, rice flour, gelatinised corn flour, germinated rice flour and mixture of the flours (Hussein *et al.*, 2012). Although the fat contents of the cake samples were significantly different ($p \leq 0.05$), the values do not follow a particular trend, however cake sample produced with 80% brown rice (sample E) had the highest fat contents (25.43%). The

variation in the fat contents of the samples could be due to differences in their binding properties with the fat used in the preparation of the cakes. The value reported in this study was higher than the value reported in the cake made from composite flour from sweet potatoes and brown rice (Onyekwelu *et al.*, 2021).

The ash content of the cakes samples increases with increased in the proportion of brown rice flour in the blends. Sample E with highest proportion (80%) of brown rice had the highest ash content (1.78). This could be due to high ash contents in brown rice. According to Bolarinwa *et al.* (2019), the ash content of brown rice is 1.29%. The fibre contents of the cakes increases with increment in the proportion of the brown rice in the cake preparation. This could be due to high fibre content (5.27%) in brown rice (Bolarinwa *et al.*, 2019). The ash contents of the cake samples reported in this study is lower than the crude fibre (10.2%) of gluten-free cake from 40% chickpea flour, 30% brown rice flour and 30 % pumpkin seeds (Agarwal *et al.*, 2020). The variation in the fibre contents of the cakes could be due to differences in the ingredients used for their preparation. The carbohydrate content of the cake sample produced with 40% brown rice flour and 40% corn flour (sample D) was the lowest (38.05%). This could be due to lower proportion of brown rice in the blend. The carbohydrate contents of the cake samples is similar to the carbohydrate content (44.2%) of gluten-free cake from 70% chickpea flour and 30% brown rice flour (Agarwal *et al.*, 2020), but lower than the carbohydrate content (74%) of standard/conventional cake (Agarwal *et al.*, 2020). This indicates that the gluten-free cake cannot contribute significantly to the caloric intake of the consumers.

Table 1: Proximate Analysis and Physical Properties of Gluten-Free Cakes

Sample code	Protein (%)	Moisture (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrates (%)	Cake height (cm)	Specific volume (cm ³ /g)
A	10.22 ^b	23.50 ^b	18.67 ^a	1.57 ^b	1.28 ^{ab}	44.76 ^d	2.71 ^b	2.26 ^b
B	10.15 ^{ab}	23.83 ^b	19.08 ^a	1.68 ^c	1.25 ^b	44.01 ^c	2.97 ^c	2.44 ^c
C	10.08 ^a	24.00 ^c	21.33 ^b	1.64 ^c	1.23 ^b	41.72 ^b	2.73 ^b	2.28 ^b
D	9.75 ^a	24.57 ^c	25.00 ^c	1.46 ^a	1.17 ^a	38.05 ^a	2.70 ^b	2.22 ^b
E	10.28 ^b	20.67 ^a	25.43 ^c	1.78 ^d	1.30 ^c	40.54 ^b	2.55 ^a	2.06 ^a

Values are means of triplicate analyses. Means within the same column with different superscripts are significantly different ($p \leq 0.05$). A = 60:20:20 (brown rice: tapioca: corn flour); B = 55:20:25 (brown rice: tapioca: corn flour); C = 50:20:30 (brown rice: tapioca: corn flour); D = 40:20:40 (brown rice: tapioca: corn flour); E = 80:20:0 (brown rice: tapioca: corn flour).

Physical properties of gluten-free cakes

The physical properties of the cake samples are presented in Table 1. The heights and volume of the cake samples decreases with increasing proportions of brown rice in the cake blends. The cake sample produced with 55% brown rice flour and 25% corn flour (sample B) recorded the highest value for height (2.97 cm) and specific volume (2.44 cm³/g). On the other hand, the cake sample from 80% brown rice (sample E) had the least height value (2.55 cm) and

specific volume (2.06 cm³/g). This could be due to high fibre contents of brown rice, as fibre concentration increased, specific volume decreased (Aydogduet *al.*, 2018). Nothing was made about the cake appearance as shown displayed in Figure 2

Sensory evaluation of gluten-free cakes

The sensory evaluation results of the cakes are shown in Table 2. In general, the sensory attributes scores of the cake samples were significantly different ($p \leq 0.05$) from each other except for aroma and colour. Figure 1, shows the images of the gluten-free cakes. The gluten-free cake produced from the 55:20:25 (sample B) was highly rated in terms of taste, colour aroma and overall acceptance. Although there was no significance difference ($p \geq 0.05$) in the samples in term of colour and aroma. The 80% brown rice cake (sample E) received the least sensory rating among all the samples. This could be due to the high fibre contents in brown rice which contributed to the hardness of the cake. According to Aydogduet *al.* (2018), as fibre contents increases in food, the hardness increases. The bland flavour of brown rice also contributed to the lower rating of the control sample (sample E).

Table 2: Sensory evaluation of the gluten-free cake

Sample code	Taste	Colour	Texture	Aroma	Overall Acceptance
A	5.60±1.04 ^a	6.12±1.09 ^a	6.11±0.77 ^a	6.48±0.65 ^a	6.52±0.77 ^a
B	7.02±0.88 ^a	6.80±1.07 ^a	6.17±1.43 ^a	6.96±0.98 ^a	7.32±0.95 ^b
C	6.16±1.89 ^b	6.32±1.15 ^b	6.36±1.98 ^b	6.72±1.51 ^b	6.84±1.49 ^c
D	6.24±2.09 ^c	6.14±1.57 ^b	6.64±2.50 ^b	6.72±1.57 ^b	6.80±1.58 ^d
E	5.16±0.14 ^d	6.02±0.58 ^c	5.59±0.55 ^c	6.12±0.21 ^c	5.91±0.62 ^e

Sample codes are as described in Table 1 (above)



Figure 3: Images of gluten free cake from blends of brown rice flour, tapioca starch and corn flour

Conclusion

This study has demonstrated the potential of brown rice flour and corn flour for cake making. Gluten free-cake produced from 55:20:25 (brown rice: tapioca starch: corn flour) had appreciable concentration of protein content, ash and crude fibre contents. The cake sample also had the highest specific volume and height, in addition to being highly rated in terms of taste, colour, aroma and overall acceptance. Thus, this study recommends the production of gluten free cake with 55:20:25 (brown rice: tapioca starch: corn flour) formulation. The use of brown rice flour in cake making will add value to broken brown rice which are mostly used as animal feed in Nigeria because of its unacceptance by consumers. In addition, the gluten-free cake will add to cake varieties for people with celiac disease. Commercialisation of this product will reduce the dependency of Nigeria on importation of wheat flour. Further study should optimise the formulation and processing conditions for the cake production, and also determine the storage stability of the gluten-free cake.

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AMYLOSE AND ASH CONTENTS OF FARO 67 RICE VARIETY PARBOILED USING DIFFERENT SOAKING AND STEAMING TIMES

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Abstract

The effect of soaking and steaming (parboiling) times on the amylose and ash contents of Faro 67 rice variety was investigated. Faro 67 rice paddy was soaked and steamed using a combination of 16 soaking and steaming times (4,6,8 and 10 hours/25,30,35 and 40 minutes), dried and milled. The amylose and ash contents of the rice grains were measured using standard methods and data generated were subjected to one way analysis of variance. The results showed that parboiling time had significant ($p < 0.05$) effect on the amylose and ash contents of the rice. Values of amylose were between 29.00% and 60.72% (for samples soaked/steamed for 6 hours/35 minutes and 4 hours/35 minutes respectively) while ash contents were between 0.66% and 1.82% (for samples soaked/steamed for 6 hours/35 minutes and 8 hours/40 minutes respectively). However, it can be resolved that in choosing the optimum steaming time for rice manufacturing industries, steaming times of ≥ 30 minutes is recommended. This will further improve the deficiency of rice mill as well as increasing nutritional value.

Keywords: *Rice, Soaking, Steaming, Amylose, Ash*

1.0 INTRODUCTION

Rice (*Oryza sativa*) is a good source of essential nutrients, especially carbohydrate (Puncha-ar-non and Uttapap, 2013). Rice is grown in all the ecological zones of Nigeria with different varieties, processing, and adaptation traits for each ecology (Sanniet *al.*, 2005). Nutritionally, rice grain contains 75 -80% starch, 12% water, and 7% protein; minerals like calcium, magnesium, phosphorous, iron, copper, zinc and manganese in trace amount (Okoet *al.*, 2012). Rice is an economic crop which is important in household food security, ceremonies, nutritional diversification, income generation and employment (Nwalieji, 2016). It is utilized mostly at the house hold level where it is consumed as boiled, fried or ground rice with stew or soup. Rice provides 45% of calories and 40% total protein requirement of an average population (Mendis and Sri Lanka, 2006). Rice grain also contains sugar, fat, dietary fiber and minerals such as Mn, Pd, Zn, Fe and Cu. Parboiling is a hydrothermal process consisting of soaking, steaming, and drying operations modifying the qualitative and processing behaviour of rice. This change is accomplished by soaking in hot water and steaming at low pressure, before drying and milling the rice (Shittuet *al.*, 2012).

Starch content of rice decreases due to leaching of starch granules (Sareepuanget *al.*, 2008). Starch mainly consists of amylose (linear) and amylopectin (branched) molecules. Free and

lipid-complexed amylose contents are the most important constituents of rice which decides gelatinization behaviour, pasting properties, cooking qualities, and glycemic index of rice (Lambert *et al.*, 2009). Soaking decreases the amylose content due to leaching thereby reducing rice quality. Ash content of a food sample gives an idea of the mineral element present in the food sample. Ash residual is generally taken to be a measure of the mineral content of materials. High ash content in milled rice is an indication of a good quality of minerals in the rice sample (Dipti *et al.*, 2003).

The objective of this study is to determine the effect of length of soaking and steaming on the amylose and ash content of Faro 67 rice variety.

2.0 MATERIALS AND METHODS

2.1 Materials

FARO 67 (low land rice) rice variety was obtained from the Rice Breeding Division of National Cereals Research Institute (NCRI), Badeggi, Nigeria.

2.2 Preparation of samples

A laboratory water bath (HH- W600, Guo Hua Electrical appliance Co, Ltd China). with temperature regulation of $\pm 2^{\circ}\text{C}$ was used for soaking rice grains at 70°C for 4, 6, 8 and 10 hours before steaming at different times of 25, 30, 35 and 40 minutes to produce parboiled rice. Replicate 1kg of the rice sample was put in a cloth bag and tied loosely before placing inside the soaking water bath. For each soaking time, four of such bags were placed inside the water bath. The temperature of the soaking water was maintained at the desired level and time and samples were then removed for steaming in a locally fabricated steaming vessel. After steaming, the rice (paddy) were dried using solar DehytrayTM dryers. A laboratory model rubber roll rice sheller (THU 35B, Satake Engineering Corp. Tokyo, Japan) with a capacity of 50kg/h was used to de-husk the 1kg of parboiled rice.

2.3 Determination of amylose and ash contents

Amylose content was determined according to the method of (Asghar *et al.*, 2012). Rice (0.1g), 1N sodium hydroxide (9 ml) and ethanol (1 ml) were mixed in a 100 ml volumetric flask. The starch in the sample was gelatinized by heating the samples for 10 minutes in boiling water bath and then cooled to room temperature. Iodine solution (2 ml) and 1N acetic acid (1.0 ml) were added to about 5 ml of the gelatinised sample in a separate 100 ml volumetric flask. Distilled water was then added to the 100 ml mark and the absorbance (A) read with a UV-spectrophotometer.

Ash content was determined using the method described by (AOAC 2010). The ash content was determined after incineration of 2g of the sample in a muffle furnace at 550°C for 2 hours

until a light grey ash was obtained. It was cooled in a desiccator, weighed and the ash content calculated as:

$$\% \text{ Ash} = \frac{\text{weightloss}}{\text{weightofsample}} \times 100$$

Statistical analysis was carried out to one-way analysis of variance (ANOVA) and T- test was done to analyze the significance in the variation of means between the samples as well as to analyze the significance in the variation of mean.

3.0 RESULT AND DISCUSSION

Table 1 below shows the amylose content (%) of the rice samples. The amylose content ranged between 29.00% and 60.72% (for samples soaked/steamed for 6hours/35minutes and 4hours/35minutes respectively) the increase may be due to heat treatment given to the sample and the result does not agree with the work of (Ogunbiyi *et al.*, 2019) with the value recorded 27.22% to 32.18%. Low amylose content in rice flour promotes an increase in moistness, chewiness and soft texture in food manufacturing, where as high amylose content in rice contribute to increase in firmness and crispness in food products (Wang *et al.*, 2016). Amylose content aid the overall cooking, eating and pasting properties (Thomas *et al.*, 2013). Ash content gives an idea of mineral content present in the food. The ash content ranges from 0.66% and 1.82% (for samples soaked/steamed for 6 hours/35 minutes and 8 hours/40 minutes) respectively (Table 1). This may due to migration of mineral salts during soaking and steaming steps and the value is slightly higer than that of Vunain *et al.*, (2020) who also gave the ash range 0.69% to 0.90% . Some reduction in ash content that were observed might be due to leaching out of both macro and micro elements into cooking water (Edeogu *et al.*, 2007). In flour products, ash is a quality parameter which influences the colour of products.

Table 1: Amylose and Ash content of differently soaked and steamed Faro 67 rice variety

Sam- ples	Amylose		Ash	
A1	37.47 ^{fg} ±0.02		1.21 ^{de} ±0.00	
A2	29.40 ^h ±0.01		1.22 ^d ±0.00	
A3	60.72 ^a ±0.02		1.08 ^{fg} ±0.01	
A4	50.27 ^{bc} ±0.27		0.84 ⁱ ±0.01	
B1	45.61 ^d ±0.11		1.34 ^c ±0.02	
B2	30.06 ^h ±0.05		0.99 ^h ±0.01	
B3	29.00 ^h ±0.00		0.66 ^k ±0.03	
B4	51.67 ^b ±0.07		0.74 ^j ±0.03	
C1	35.07 ^g ±0.02		1.38 ^c ±0.06	
C2	37.68 ^{fg} ±4.98		1.68 ^b ±0.02	
C3	50.66 ^{bc} ±0.03		1.31 ^c ±0.01	
C4	44.25 ^{de} ±0.04		1.82 ^a ±0.02	
D1	40.75 ^{ef} ±0.05		1.38 ^c ±0.02	
D2	51.40 ^b ±0.31		1.04 ^h ±0.01	
D3	47.14 ^{cd} ±0.07		1.14 ^{ef} ±0.02	
D4	60.52 ^a ±0.02		1.06 ^{fg} ±0.02	

KEY: Mean in the same column with different superscript are significantly different from each other.

Key: A1= 4hr/25min, A2= 4hr/30min, A3= 4hr/35min, A4= 4hr/ 40min, B1= 6hr/25min, B2= 6hr/30min, B3= 6hr/35min, B4= 6hr/40min, C1= 8hr/25min, C2= 8hr/30min, C3= 8hr/35min, C4= 8hr/40min, D1= 10hr/25min, D2= 10hr/30min, D3= 10hr/35min, D4= 10hr/40min.

4.0 CONCLUSION

From the result of this study it can be concluded that higher steaming times produced better results irrespective of the soaking time with respect to amylose content but the reverse was the case with ash content. This will further improve the deficiency of rice mill as well as increasing nutritional value. No particular pattern was observed with respect to soaking times.

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EFFECTS OF WHEAT MALT INCLUSION ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF WHEAT-CASSAVA AND WHEAT-SWEET POTATO BREADS.

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Abstract

Sprouting leads to increase in enzymatic activity and this has been utilized to enhance bread quality. Root flours are known to have low diastatic activity. In this study, 10-30% each of cassava (C) and Sweet potato (S) flours were separately blended with 5-10% wheat malt (M) and undeveloped Norman (W) flour. The formulations were: 85:10:5, 70:20:10, 60:30:10 (WCM/WSM) and 100:0:0, and replicated control for each set. The breads were evaluated for physicochemical and sensory properties. Specific loaf volumes (SLV) were higher in the two controls (6.24ml/g and 6.01ml/g) and decreased progressively in the treated. For WSM breads, SLVs were 4.39-3.95ml/g and 4.32-3.3ml/g for WCM. Sensory attributes of the controls were better and decreased with higher level of C or S addition. There were little variations in the attributes among the treated, however 30% substitution yielded poorer attributes. The protein contents decreased slightly in both WCM and WSM breads and lipid decreased only in the WCM breads. Ash levels were higher in the treated while fibre contents progressively increased in WCM, unlike in WSM breads. Calorific values were slightly higher in the treated. At the level of 20% root flour and 5% wheat malt, SLV of the treated were relatively higher when compared with literature values for wheat-root/tuber breads. It is concluded that breads with high SLV could be produced with 10% wheat malt and 20% C or S flour.

Keywords: Norman (wheat grain), Wheat malt, Cassava flour, Sweet potato flour, Composite bread.

Introduction

Roots and tubers flours are known to contain lower amount of protein and by implication lower amylase activity than found in wheat flour. Therefore, partial replacement of wheat flour with root flour will definitely yield blends with reduced gassing power. Oladunmoye et al. (2014) reported 96mg/10g and 260 for maltose figure and falling number for cassava flour (CF) against 244mg/10g and 707 for wheat semolina. Similarly, Nabubuya et al. (2012) observed in a study that fresh sweet potato roots contain very little diastase which increases during storage coinciding with sprouting; maltose equivalents of 3.7-10.4mg/g for flours produced from five sweet potato varieties was reported. Sprouting of grains activate and elevate endogenous amylolytic and proteolytic enzymes leading to an increase in the concentration

of free amino acids, simple sugars, fatty acids, minerals, B-vitamins and non-nutrient phytochemicals. Consequently, there is slight reduction in the dry matter content of malted flour. Diastatic power or maltose figure is a measure of the amount of diastase (α - and β -amylases) available for saccharification during dough proofing. Diastatic malt promotes a strong rise, great texture and brown crust in baked goods. Inclusion of malt flour(enzymes) in composite flours enhances gassing power, help degrade anti-nutrients and reduce or modify polymers to readily absorbable units and this helps to reduce digestive upset in patients with coeliac disease or gluten sensitivity. Hugo(2015) reported that 30% boiled malted sorghum produced bread with softer moist crumb and finer flavour than the same bread with 30% un-malted sorghum flour. Khalil et al.(2000) found that 1% barley malt inclusion in wheat-cassava bread formulation at substitution levels of 20% and 30% produced bread with better loaf height, oven spring and specific loaf volume (SLV) than the untreated. Sivakanthan et al.(2012) on the other hand replaced wheat flour with 35% rice malt and achieved the same purpose. Santiago et al. (2015) improved the gas retention of the dough and SLV by application of commercial amylase and hemicellulase to wheat-purple sweet potato powder blend. Khalil et al.(2000) however warned that excess enzymatic activity results to excessive liquefaction and dextrinization leading to wet and sticky crumb. The current study evaluated physicochemical and sensory properties of wheat-cassava and wheat-sweetpotato treated with wheat malt.

Materials and Methods

Materialcollectionsand preparations. Fresh cassava, sweet potato roots and ingredients (margarine, dried bakersyeast, granulated sugar, common salt etc) were purchased from dealers in Maiduguri. Wheat grain (Norman) was obtained from the Lake Chad Research Institute, Maiduguri.

Preparation of cassava, sweet potato, and malted wheat flours.Washed fresh roots 2.5Kg each were manually peeled, chipped, ground using an electric mill, the resulting mash was dewatered by placing in a cotton bag and subjected to pressure for 4h, and later pulverized and dried in cabinet dryer, 60°C 10h. The dried materials were further reduced to size using laboratory Hammer mill attached with 0.25mm sieve. Cassava flour (C), sweet potato flour (S) were separately packaged in LDPE bags. The procedure described by Sivakantham et al.(2012) was applied for wheat malt preparation. Sorted Norman wheat grains were soaked in tapwater (1:2 w/v) for overnight, later spread on a wetted jute bag and covered with a muslin cloth and left in the dark. Water was sprinkled 12 hourly and the grains started sprouting before 26h. Sprouted grains were dried in a hot-air cabinet dryer 50°C 8h. Dried grains were tempered and dehulled manually using mortar and pestle, air-dried before winnowing. Dehuled grains were ground in a laboratory hammer mill equipped with 0.25mm sieve. Again cleaned wheat grains were conditioned and decorticated in a local mill and air dried which enabled winnowing, the same were ground in a laboratory mill equipped with 0.250mm sieve. Both the malted wheat (M) and un-malted wheat(W) flours were packaged in LDPE bags and left at room temperature prior to use.

Blend formulation. Wheat flour (W) was blended with 10-30% cassava (C) flour (3 formulations) and with 10-30% sweet potato (S) flour (another 3), finally 5-10% wheat malt (M) were added to each blend. The formulations: W:C:M (100:0:0, 85:10:5, 70:20:10, 60:30:10) and W:S:M (100:0:0, 85:10:5, 70:20:10, 60:30:10), a total of eight, because the control accompanied the baking of each set). Each blend was mixed thoroughly in a kitchen blender (MC-B180, Crown Star, China) and separately packaged in LDPE bags prior to baking.

Bread making. Straight dough method (10-10B AACCC(2000) was applied with slight modification for bread making using the following recipe: 100g flour, 5g sugar, 1.0g dried yeast, 1.0g salt, 6g margarine, 55-65ml water. All dried ingredients were mixed, later activated yeast cells were added and mixed, the water was gradually added and the dough transferred unto a greased board and fat was rubbed in and kneaded. Dough was fermented for 90 min in proof chamber, 85% RH, 30±2°C. Dough was knocked back and degassed on a greased board. It was portioned (200g pieces), rounded and placed in the greased pans, proofed for 60min and finally baked at 200°C, 30min. Cooled loaves were weighed and volume obtained using the pearl millet seed displacement method, the values were used to calculate the specific loaf volumes.

Sensory Evaluation. Sixteen member panel of judges comprising of eight males and females of the Department evaluated the following bread attributes: taste, crumb texture, crumb grain, loaf symmetry, flavor on a 9-point Hedonic scale: extremely liked(1), neither liked nor disliked(5) and extremely liked(9). Coded sliced and unsliced loaves were presented to the judges in addition to warm water for mouth gargling.

Proximate composition analysis. Moisture, crude protein (%Nx6.25), crude fiber, crude fat, total ash contents of the various breads were determined according to the approved procedures of AACCC(2000), carbohydrate contents were obtained by 'difference' and energy values were calculated using the Atwater conversion factors.

Statistical analysis. Mean and standard error of the mean of the values were calculated, mean values were separated using Duncan's Multiple Range Test and significance was set at a p-value of 5%. Statistical package for social sciences (SPSS, ver. 17.0) was used for statistical analysis of the obtained data.

RESULTS AND DISCUSSION

The main factors responsible for the variations in the proximate composition of the various breads were the sweet potato (S) and cassava flours (C) in the formulations, WSM & WCM formulations respectively and they are starchy materials, and the wheat flour (W) which was ground without being degermed as done in commercial white flour milling(**Table 1**), therefore richer than ordinary refined wheat flour, and the malted wheat (M) included in the formulation not necessarily for quantitative nutrient enhancement but qualitative, mainly bread volume enhancement. There were slight increases in the moisture contents of WSM bread (27.80-

29.14%) with increased substitution of W with either S or C flour, and more narrower range of moisture content was observed in WCM breads (27.10-27.51%), the range obtained in this study is not far from 29.40-30.05% reported by Sivakanthamet al.(2012)for rice-malt bread but lower than 35.37-39.72% for wheat-cassava bread produced from different cassava varieties and substitution levels reported by (Eleazu et al.,2014). Protein contents of the WSM breads (8.04-7.57%) were the same statistically, in WCM breads the protein content of formulations 85:10:5 and 70:20:10 were not different from the control (9.63%). In WSM breads there were progressive but slight increase in total ash(1.52-1.90%), lipid (1.71-1.90%), carbohydrate (42.07-43.50%) but insignificant decrease in fibre (3.00-2.75%) and protein (8.04-7.57%) with increased S flour addition but in WCM breads, a similar variations occurred though not clear cut, yet there was a slight decrease in protein (9.63 -7.40%) and lipids with substitution of W with C flour and M therefore the ash (1.60-2.14%), fibre (3.21-3.75%), lipids (2.85-2.70%), protein (2.70-2.85%) increased and insignificant increase in fibre (3.21-3.75%). Both WSM & WCM breads had carbohydrate contents between 42 and 44% and in each case lower in wheat bread than in composite breads. Slightly lower calorific values in the breads reflected lower lipid, protein and carbohydrate contents.

Table1. Proximate composition(%) of wheat-cassava and wheat-sweet potato breads treated with wheat malt.

Formulations	Moisture	Protein	A s h	L i p i d	Crude fibre	C	H	O	E(kcal)
W : S : M									
1 0 0 : 0 : 0	27.80±0.40 ^a	8.04±0.08 ^a	1.52±0.05 ^b	1.71±0.06 ^a	3.00±0.03 ^a	42.07±0.43 ^a	215.83		
8 5 : 1 0 : 5	28.31±0.23 ^a	7.57±0.10 ^b	1.71±0.02 ^a	1.83±0.06 ^a	2.90±0.03 ^a	42.32±0.60 ^a	216.03		
7 0 : 2 0 : 1 0	28.85±.15 ^a	7.80±0.13 ^b	1.81±0.01 ^a	1.89±0.02 ^a	2.81±0.05 ^a	42.16±0.18 ^a	216.85		
6 0 : 3 0 : 1 0	29.14±0.10 ^a	7.75±0.06 ^b	1.90±0.01 ^a	1.90±0.01 ^a	2.75±0.03 ^a	43.50±0.25 ^a	222.21		
W : C : M									
1 0 0 : 0 : 0	27.10±0.29 ^a	9.63±0.09 ^a	1.60±0.05 ^a	2.85±0.06 ^a	3.21±0.06 ^b	44.39±.23 ^a	225.66		
8 5 : 1 0 : 5	27.32±0.21 ^a	9.37±0.12 ^{ab}	1.82±0.07 ^b	2.80±0.10 ^a	3.50±0.07 ^a	44.81±.32 ^a	243.41		
7 0 : 2 0 : 1 0	27.51±0.15 ^a	8.00±0.10 ^b	1.95±0.03 ^a	2.72±0.05 ^a	3.61±0.07 ^a	43.79±0.19 ^a	231.64		
6 0 : 3 0 : 1 0	28.42±0.19 ^a	7.40±0.06 ^a	2.14±0.04 ^a	2.70±0.07 ^a	3.75±0.07 ^a	44.41±0.21 ^a	231.51		

Values are mean±SE(n=2). Means followed by the same superscript are significantly not different(p>0.05). M: wheat malt, S:sweetpotato flour , W: undegermed wheat flour, C: cassava flour.

Bread volume is the most important determinant of consumer acceptability and sales turnover. Bread improvers are applied to enhance bread quality chiefly loaf volume. In this studythere were progressive decline in weight, volume, and SLV for both wheat-cassava-malt (WCM) and wheat-sweetpotato-malt (WSM) breads respectively 180.89-173.80g, 1087.50-582.80ml, 6.01-

3.31ml/g and 182.25g-175.27g, 1148-695ml, 6.24-3.95ml/g) with increased addition of root flours (C and S) (**Table 2**). The enhanced loaf volumes in the treated beyond the usual lower values reported in the literature could only be linked to wheat malt addition. Khalil et al.(2000) had earlier reported that acceptable bread at 20% and 30% substitution of wheat flour with cassava flour was possible with 1% barley malt inclusion. Sivakanthan et al.(2012) reported significant higher SLV for wheat bread (5.84ml/g) than 5.31ml/g for malted rice malt-wheat bread and 2.3ml/g ordinary rice-wheat bread. Addition of commercial α -amylase and hemicellulase to wheat-purple sweet potato powder bread enhanced the SLV(4.73ml/g) more than obtained in the control (4.70ml/g) (Santiago et al., 2015). Similar scenario played out in this study, the SLV of the wheat bread produced alongside WSM & WCM were respectively 6.24 and 6.01ml/g. These high SLV values dropped in the composite breads, 4.39-3.95ml/g for WSM and 4.32-3.94ml/g for WCM. That the malt added was effective in enhancing the bread volume is confirmed by the report from Chisenga et al. [8] who reported SLV of between 1.5 to 2.5ml/g for wheat-cassava bread involving different cassava varieties and substitution levels of wheat flour, and 2.48-2.62ml/g for wheat-sweetpotato bread reported by Oluwalana et al.(2012). Wheat bread had the best sensory scores which declined in the composite breads and among the later significant variation was not observed between some attributes both in WSM & WC breads, an indication that C & S levels were the main factors influencing the bread attributes since the level of M was low (5-10%) (**Table 2**). Among the WSM breads, flavour, a twin effect of aroma and taste were improved with increase in S flour addition, perhaps due to inherent sweet nature of sweetpotato, texture was better in the formulations containing 10% M, but crumb grain of bread with 5% M and 10% C and the control were not significantly different, and the symmetry of WSM improved with increased in S addition. Among the WCM breads flavour, grain, texture and symmetry deteriorated with increased addition of C flour. With 40% rice malt addition, Sivakanthan et al.(2012) reported the poorest crumb structure and mouth feel satisfaction, but below 40% level flavour, crust texture and attributes of rice malt-wheat bread were not different from the control.

Table 2 Physico-sensory properties of the wheat-sweetpotato and wheat-cassava breads treated with wheat malt

Formulations	Loaf weight (g)	Loaf vol(ml)	Specific vol(ml/g)	Flavour	Crumb Grain	Crumb texture	Loaf Symmetry
W : S : M							
1 0 0 : 0 : 0	182.25±3.18 ^a	1148±9.61 ^a	6.24±0.05 ^a	8.50±0.84 ^a	8.00±0.67 ^a	8.30±0.50 ^a	8.80±0.32 ^a
8 5 : 1 0 : 5	177.75±1.77 ^b	790±11.14 ^b	4.39±0.07 ^b	6.80±0.79 ^c	8.00±1.35 ^a	6.70±1.42 ^b	7.00±1.56 ^b
7 0 : 2 0 : 1 0	175.27±1.06 ^b	758±3.54 ^b	4.32±0.01 ^b	7.10±0.88 ^b	7.00±0.67 ^b	6.80±1.14 ^b	7.30±1.06 ^b
6 0 : 3 0 : 1 0	176.40±0.57 ^b	695±7.07 ^c	3.95±0.01 ^c	8.30±0.82 ^{ab}	6.60±0.82 ^b	7.70±1.16 ^b	8.30±0.07 ^a
W : C : M							
1 0 0 : 0 : 0	180.89±0.35 ^a	1087.50±8.64 ^a	6.01±0.01 ^a	8.33±0.49 ^a	7.87±0.83 ^a	7.33±0.90 ^a	8.00±0.76 ^a
8 5 : 1 0 : 5	175.30±1.56 ^b	760.00±7.07 ^b	4.32±0.03 ^b	6.87±1.30 ^b	7.02±0.65 ^b	7.40±1.00 ^a	7.40±0.74 ^b
7 0 : 2 0 : 1 0	173.80±0.47 ^b	697.50±3.54 ^c	3.94±0.10 ^c	6.33±1.35 ^b	7.07±0.80 ^b	6.73±1.03 ^b	6.80±1.15 ^c
6 0 : 3 0 : 1 0	174.51±0.29 ^b	582.80±10.61 ^d	3.31±0.05 ^d	6.33±4.40 ^b	6.67±1.45 ^c	6.67±1.45 ^b	6.82±1.00 ^c

Values are mean±SE(n=3/n=10). Means followed by the same superscript are significantly not different (p>0.05). M:wheat malt, S:sweetpotato flour, W: undegermed wheat flour, C: cassava flour.

Conclusion

Bread volumes of the two formulations (WSM and WCM) were enhanced through introduction of wheat malt and the later was subjected to not more than 24h sprouting to avoid excessive proteolytic and amylolytic activities inimical to bread quality. However, SLV and sensory attributes of the treated breads were not better than the control made with undegermed flour from wheat grains (Norman) which also help to enhance the nutritive value of the various breads, offsetting the effects of introducing root flours with lower nutritive value.

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IN-VITRO PROTEIN DIGESTIBILITY AND SENSORY CHARACTERISTICS OF COOKIES PRODUCED FROM WHEAT AND NIXTAMALIZED BUCK- WHEAT FLOUR BLENDS

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ABSTRACT

The study was designed to evaluate the effects of nixtamalized buckwheat flour substitution for wheat on in-vitro protein digestibility and sensory characteristics of cookies. Unhulled buckwheat seed was subjected to a nixtamalization process using lime juice or potassium hydroxides (KOH). A varying proportion (10-40%) of nixtamalized buckwheat flour (NBW) was substituted for wheat in cookie formulation. A control sample was made from 100% Wheat. Cookies were analyzed for in-vitro protein digestibility and sensory attributes using standard methods. Data obtained (3 replicates) were subjected to ANOVA (analysis of variance) at $P \leq 0.05$ using SPSS. Supplementation of wheat with nixtamalized buckwheat flour significantly ($P \leq 0.05$) increased the protein digestibility (70.87-95.04%) with an increase in NBW. All the cookie samples were generally accepted by the panelist and compared well with cookies made from 100% flour on a nine-point hedonic scale. Nixtamalization of buckwheat improved the in-vitro protein digestibility and sensory characteristics of wheat-buckwheat composite flour-based cookies.

Keywords: Nixtamalization, Food supplementation, Cookies, Unhulled buckwheat, Lime juice.

INTRODUCTION

Cookies are ready-to-eat snacks consumed by many people worldwide because of their palatability and nutritional value (Bello *et al.*, 2020). They are tasty and possess a prolonged shelf-life due to the presence of low moisture since they have undergone drying processes (Bello *et al.*, 2020). Commonly wheat flour is one of the key ingredients needed to produce cookies. Wheat provides more calories and proteins than any other cereal crops (Kumar *et al.*, 2011). It is rich in protein, minerals, B-group vitamins and dietary fiber (Kumar *et al.*, 2011; Afzal *et al.*, 2013). Recently, there has been a lot of research on the utilization of local crops as composite flour in the production of bakery products such as cookies, bread etc. (Chopra *et al.*,

2014; Najjaret *et al.*, 2014; Eberet *et al.*, 2015; Briteset *et al.*, 2019; Bello *et al.*, 2020). Largely, the practice is for health benefit improvement, in addition to basic nutrients but sometimes for cost reduction purposes. Buckwheat, an underutilized crop, reported to have originated from Asia and which is now widely cultivated worldwide (Mahata, 2018) had been commonly used as gluten-free alternative in this art. It is known as a pseudo cereal with similar properties to cereals. In general, the grain serves as food for human and as poultry feed. The dehulled grains can be cooked as porridge and the flour is used in the production of pancakes, biscuits, noodles, cereals, etc as reported by Mahata (2018). Buckwheat has been reported to be rich in protein with a high content of essential amino acid lysine, compared to the common cereals (Mahata, 2018; Chopra *et al.*, 2014). It has been reported to be rich in minerals such as zinc, copper and manganese (Vojtišková *et al.* 2012; Chopra *et al.*, 2014). Vojtišková *et al.* (2012) reported that buckwheat is rich in dietary fiber which helps to improve the function of the gastrointestinal tract and also aid the metabolism of other nutrients. Buckwheat is gluten-free which makes it considered healthy for people with celiac disease (Vojtišková *et al.* 2012). Additionally, buckwheat has been reported to contain chemical compounds like rutin, catechins and other polyphenols with improved activity in lowering the blood cholesterol, in preventing high blood pressure, controlling blood sugar and preventing risk of cancer (Chopra *et al.*, 2014; Mishra and Jain, 2019). It also possesses a great amino-acid composition with a good biological value (Ikeda *et al.*, 1991; Ikeda and Kishida, 1993).

However, studies have shown that the digestion and absorption of buckwheat protein are low in animals and humans. This problem may be due to the presence of antinutrients like phytate, tannin, oxalate saponin, and protease inhibitors in buckwheat (Ikeda *et al.*, 1991; Ikeda and Kishida, 1993). Mattila *et al.* (2018) in their studies, reported that the strongest inhibition of trypsin was found in buckwheat which may be due to the presence of protease inhibitor or other antinutrients in buckwheat. Hence, there is need for further treatment of buckwheat seed using a specific technique before utilization. One of the adopted techniques for improving nutrient content in cereals (mostly maize) is nixtamalization. Nixtamalization is done by cooking and soaking in an alkaline solution (AIP Proceedings, 2019). Nixtamalization has been reported to provide health benefits such as lowering the mycotoxin content in cereal, reducing the risk of pellagra disease as a result of the increase in the availability of niacin, improving the intake of calcium and also improves the source of fibre (Palacios *et al.*, 2016). Several works have been done on the nutritional composition of cookies using various composite flour but much has not been reported on the use of blends of common wheat and nixtamalized buckwheat flour. Therefore, the aim of this study was to evaluate the impact of nixtamalization on the invitro protein digestibility and sensory characteristics of wheat-buckwheat-based cookies.

MATERIALS AND METHODS

Sources of Materials

The whole buckwheat was procured from Lagos, Nigeria. The wheat flour, lime fruits, date powder, margarine, and other ingredients used in cookie preparation were purchased from

bakery stores in Ilorin, Nigeria. Dehulling and Milling of Buckwheat were conducted at the Food Science and Technology laboratory, Kwara State University, Malete, Nigeria.

Methods

Processing of lime juice

The lime fruits were washed and cut into two transverse sections with a sharp knife. The juice was extracted manually by squeezing with the hand. The juice containing the seeds and some particles was filtered and stored in a plastic container prior to processing.

Production of nixtamalized buckwheat flour

The method of DoralindainRaïet.al., (2010) was used with modification. The unhulled buckwheat seeds were cleaned by an application of aspirator. The cleaned unhulled buckwheat seeds were then washed and steeped in excess water for 10 minutes. The water was changed 2-3 times during the steeping period. At the end of steeping period, the unhulled buckwheat seeds were washed again and drained afterwards. Alkaline solution was prepared and added to a pot filled with water then heated to boiling point, then the steeped buckwheat groats were added to the heated alkaline solution and allow to heat up for 6 minutes. Afterwards, the pot which contained the nixtamalized was removed from heat and allowed to steam for 10 minutes. The contents in the pot were then drained and the water was discarded. Thorough washing of the nixtamalized buckwheat was done under running water to remove the pericarp and excess solution and drained afterward for drying. After the nixtamalization process, the nixtamal was oven-dried at $38 \pm 10^{\circ}\text{C}$ for 30-45 minutes. Grinding of the dried groats was done using a burr mill. Nixtamalized buckwheat flour was sieved through 52 mesh size, stored at room temperature and packaged in polyethylene bags pending uses.

Composite flour development and cookies preparation.

By incorporating a (0-40%) of Nixtamalized Buckwheat flour (NBW) into wheat flour (WWF) composites were developed and coded DKT (100%), BOX (90:10%), YOB(80:20%), KZT(70:30%) and AOB(60:40%) respectively. 100% NBW flour was used as named CMD sample. Formulation was done in such a way that all ingredients like Margarine, Salt, Eggs, Baking powder, vanilla and sucrose were kept constant according to Olatoye et al; (2019). Thereafter, the method described by Eneche (1999) was used to prepare cookies with slight modifications. The baking was done at 150°C for 20 minutes and allowed to cool for 30 minutes. The cookies were then packed into a polyethylene sachet, labelled and sealed prior to analyses.

Determination of invitro protein Digestibility

In Vitro Protein Digestibility was done according to the method by Afifyet al. (2012) with reference to ISO-16634-1 International Standard. One gram of the sample was added to 15ml (0.1M) HCl containing 1.5mg pepsin and incubated for 3 hours at 37°C . 7.5 ml (0.2M) NaOH was then used to neutralize the obtained suspension which was then treated with 4 mg of pancreatin in 7.5 ml (0.2M) phosphate buffer (PH 8.0). Toluene was added to prevent microbial growth and mixture was shaken and incubated for another 24 hours. After the incubation

period, 10 ml of 10% TCA was added and centrifuged for 20 minutes to remove the undigested protein and larger peptides from the sample. Kjeldahl method (AOAC, 2012) was used to estimate the protein in the supernatant. Nitrogen in a blank sample was also estimated.

Protein digestibility was calculated by the equation 2;

ProteinDigestibility % = $\frac{\text{NitrogeninSupernant} - \text{NitrogeninBlank}}{\text{NitrogeninSample}} \times 100$...equation (1)

NitrogeninSample

Sensory Evaluation of Cookies Produced from Wheat and Buckwheat Flour Blends.

Sensory evaluation was carried out using 30 untrained panelists. The samples were scored for colour, flavor, crispiness, Hardness, and general acceptability using a 9-point hedonic scale, where “9” represented like extremely and “1” represented dislike extremely, (Iwe, 2002)

Statistical analysis of data

All tests were replicated and data obtained were statistically analyzed using a one-way analysis of variance (ANOVA) and means were separated by Duncan’s Multiple Range Test (DMRT) using the Statistical package for social science (SPSS) IBM VERSION 21.0 package (Armonk, New York). Significance was accepted at the 0.05 probability level.

RESULTS AND DISCUSSIONS

Impact of Nixtamalization Process on the protein digestibility of Cookies Produced from

Wheat-Nixtamalized Buckwheat Flour Blends

Nixtamalization process significantly ($P \leq 0.05$) increased the protein digestibility of the formulated cookies as presented in (Table1). The protein digestibility values ranged from 70.87% to 95.04% and increases with in amount of NBW in cookies formulation. Samples DKT and CMD had the least and highest values of protein digestibility respectively. Nixtamalization process has been reported to aid digestibility and bioavailability by reducing the contents of antinutrients such as phytate, tannin, oxalate saponin, and protease inhibitors in buckwheat (Ikeda et al., 1991; Ikeda and Kishida, 1993). Mattila *et al.* (2018) in their studies, reported that the inhibition of trypsin by this process in maize. Nixtamalization was also reported to provide health benefits such as lowering the mycotoxin content in cereal, reducing the risk of pellagra disease as a result of the increase in the availability of niacin, improving the intake of calcium and also improves the source of fibre (Palacios *et al.*, 2016). It has enhanced the amino acid profile of cereals (Escalante-Aburto, *et al.*, 2019; Daz González *et al.*, 2019). Thus increased protein digestibility in this work is as expected and it is a plus to the nutritional and health benefits of buckwheat based product and could be considered a veritable retreatment option in its utilization.

Impact of Nixtamalization Process on the Sensory Attributes of Cookies Produced from Wheat-Nixtamalized Buckwheat Flour Blends.

As shown in Table 2, substitution of NBW for WF significantly ($P < .05$) influenced the sensory attributes of the cookie samples. Colour decreases with increase in NBW and sample containing 100% NBW was adjudged the least by the panelist in terms of color. This finding shares similar trend with result documented by Olatoye and Arueya, (2021), in similar study. It could be attributed to differences in composite's chemical constituents. In proper judgment of cookies sensory quality, great importance had been given to colour. This is not only because it provides basic data regarding the suitability of raw material used for its preparation, but also its formulation and product quality (Abu-Salem & Abou-Arab, 2011; Olayiwola, *et al.*, 2012). Similarly, flavour scores varied significantly ($P < .05$) and ranged between 7.46 and 8.10. This range revealed a good acceptance, since ≥ 5 on 9-point Hedonic scale. Flavor as an attribute, combines taste and aroma impressions, and is the main criterion that determines the likeness or otherwise of a product (Abu-Salem & Abou-Arab, 2011). Therefore, flavour scores showed great likeness by the panelist, with sample DKT being liked the most. Substitution of NBW for WF resulted in decreased in crispness of the cookies. Crispiness scores ranged between 7.08 and 7.34, with sample CMD and DKT being scored the lowest and highest by the consumer panelist. This result may be as a consequence of increase in cohesive forces between the peptide bonds as protein level increases (Abu-Salem & Abou-Arab, 2011; Aluko, Brai, & Adedokun, 2013). The hardness scores of the cookies as adjudged by the panelist ranged between 6.92 and 7.18 and were not significantly different ($P < .05$) between the samples, except with 100% NBW based sample. Hardness is a measure of physical effort required to cause a material to break. In food materials, this property is commonly dependent on available moisture within the food system and it also reflect its dryness. It could be inferred that, there is a reasonable level of uniformity in the hardness of these cookies' samples, it implied that storage life of the cookies may be prolonged (Gabriel & Faith, 2014). With respect to overall acceptability, none of the samples considered rejected with scores ranging between 7.26 and 7.94. This indicated that all the cookies' samples were generally acceptable for all tested attributes, as none scored below the minimum acceptable rating of 5 on a 9-point hedonic scale (Iwe, 2002; Peryam & Pilgrim, 1957). The highest overall acceptability score (7.79) was for the 10% substitution of NBW for WF. Intuitively, consumers preferred cookies made of NBW and WF in the ratio 10:90. Acceptable cookies' were developed Nixtamalized Buckwheat and Wheat flour blends.

TABLE 1: Protein Digestibility of Cookies Produced from Wheat-Nixtamalized Buckwheat Flour

Blends		
Sample Codes	WF: NBW	Protein Digestibility (%)
DKT	100:0	70.87±0.48 ^e
BOZ	90:10	82.83±0.32 ^d
YOB	80:20	83.43±0.17 ^d
KZT	70:30	86.84±1.79 ^c
AOB	60:40	92.47±0.22 ^b
CMD	0:100	95.04±1.21 ^a

Means with the same superscript in the same column are not significantly different. ($P \leq 0.05$) NBW= Nixtamalized buckwheat flour; WF=Wheat flour

TABLE 2: Sensory Attributes of Cookies Produced from Wheat and Nixtamalized Buckwheat Flour Blends

Samples	WF:NBW	Colour	Flavour	Crispness	Hardness	Overall Acceptability
DKT	100:0	8.12±0.77 ^a	8.10±0.68 ^a	7.34±0.77 ^a	7.18±0.66 ^a	7.94±0.65 ^a
BOZ	90:10	8.06±0.68 ^a	7.90±0.62 ^a	7.26±0.57 ^a	7.06±0.47 ^{ab}	7.78±0.65 ^{ab}
YOB	80:20	8.04±0.78 ^a	7.98±0.55 ^a	7.24±0.52 ^a	7.08±0.49 ^{ab}	7.62±0.60 ^b
KZT	70:30	8.16±0.62 ^a	8.10±0.46 ^a	7.16±0.58 ^a	7.06±0.51 ^{ab}	7.66±0.59 ^{ab}
AOB	60:40	8.14±0.64 ^a	8.06±0.59 ^a	7.26±0.63 ^a	7.10±0.58 ^{ab}	7.68±0.62 ^{ab}
CMD	0:100	7.54±0.79 ^b	7.46±0.81 ^b	7.08±0.67 ^a	6.92±0.53 ^b	7.26±0.83 ^c

Means with the same superscript in the same column are not significantly different ($P \leq 0.05$)

NBW= Nixtamalized buckwheat flour; WF=Wheat flour

Conclusion

It was concluded from this research work that replacement of nixtamalized buckwheat flour with wheat flour in cookies formulation yielded cookies with improved protein digestibility and sensory characteristics. Application of nixtamalization as a pre-treatment in buckwheat could enhance the protein digestibility and acceptability of cookies.

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PROXIMATE COMPOSITION OF BLENDS OF CASSAVA *FUFU*, COOKING BANANA (*MUSA SABA*) AND AFRICAN YAM BEAN (*SPHENOSTYLISSTEN-OCARPA*) COMPOSITE FLOURS AND SENSORY QUALITY OF THE PASTE.

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Abstract

The proximate composition of blends of cassava *fufu* (CF), cooking banana (CB), and African yam bean (AYB) composite flours and the resultant sensory analysis of the reconstituted paste using simplex lattice mixture experimental design were carried out. The results revealed an overall improved nutrition and some sensory attributes in the blended composite flours and paste. The moisture contents of all the samples were below 14 % which made them desirable. The overall protein content and fat content of the blended flour samples increased as the AYB component increased in the blended samples. The ash contents of the mixtures generally increased with increase in the cooking banana flour component of the mixture. The fibre contents of blended samples significantly increased as both cooking banana and AYB increased. The sensory evaluation, based on a nine-point hedonic scale, indicated that sample number 10 which contained 33.3% CF, 33.3% CB, and 33.4 % AYB scored highest in texture (7.08) and aroma (7.00) followed by the control 1 (100 % cassava *fufu*) which scored (6.79 and 6.96) in texture and aroma, respectively. The taste (7.21) and general acceptability (7.43) of control 1 sample (100 % *fufu*) was not significantly different ($p > 0.05$) from that of pastes from sample number 10 that scored 7.17 and 7.42 for taste and general acceptability, respectively. Paste sample number 10 reconstituted from flours (33.3% CF, 33.3% CB, and 33.4 % AYB) was recommended as the most acceptable of the blended samples.

Keywords: blends, cassava *fufu*, cooking banana, African yam bean, sensory quality.

Introduction

Cooking banana (*Musa saba*: ABB group) is primarily consumed either fried, in porridge form, boiled or eaten raw when ripe. In Nigeria, *Musa saba* is available all year round in Southern part of the country but highly underutilized and thereby predisposing it to rapid post-harvest spoilage as a result of its physiological metabolic activities and high moisture content (Ogbonna *et al.*, 2016). The carbohydrate type in banana is resistant starch and non-starch polysaccharides, which have low glycemic index or low digestibility (Lehmann and Robin, 2007). Bananas are good sources of minerals especially potassium, a mineral involved in proper muscle contraction (Adeniji *et al.*, 2010). They are known as a powerful secondary antioxidant source. The antioxidant compounds identified in bananas include ascorbic acid, tocopherol, beta carotene, phenolic groups, dopamine and gallic acid (Qusti *et al.*, 2010). It is relatively cheaper as compared to dessert bananas and plantains and has been reported to be rich in minerals, and ash (Ogbonna *et al.*, 2016).

African yambean is a grain legume cultivated in Central African Republic, Zaire, East Africa, and Ethiopia for its tubers and in the south-eastern Nigeria for its edible seeds (Ndidiet *al.*, 2014). AYB is a good source of protein; its amino acid profile is comparable to those for most edible pulses (Nduet *al.*, 2014). Besides protein, AYB is a good source of fibre, carbohydrate and also rich in minerals such as phosphorus, iron and potassium (Aniedu and Aniedu, 2014).

Food enrichment can be achieved through the combination of two or more food stuff to improve the nutrient quality of the resultant food for the people who consume it. This strategy can be applied in communities where there is risk of a deficiency of the nutrient or nutrients concerned (Olapadeet *al.*, 2014). In some instances, enrichment is the easiest, cheapest and best way to reduce a dietary deficiency problem. The mixture of cassava *fufu*, cooking banana and AYB will improve the overall nutrition, increase the crops utilization as well as encourage farmers to produce more.

The aim of this study was to evaluate the proximate composition of the composite flours and determine the sensory quality of reconstituted composite flours.

Materials and Methods

Source of Materials

Freshly harvested roots of Cassava Mosaic Disease (CMD) resistant variety (TME 419), a bitter variety, was obtained from the National Roots Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria, at about 11- 12 months old after planting. Matured green cooking banana and AYB were obtained from AhiaNkwo Market in Aba North, Abia State.

Preparation of cassava *fufu* flour

The cassava *fufu* flour was produced by a method of (Etudaiyeet *al.*, 2009) with little modifications. The roots were washed, peeled, and rewashed. Then the peeled roots were cut into cylindrical sizes of 6-8 cm, and soaked in water to ferment for 3 days. Then the fermented cassava was washed and grated into a mash using locally fabricated motorized grating machine. The mash produced was put in a big plastic container, covered to protect it from flies for 2 days. Thereafter, the mash was dewatered after putting it in a clean bag using a locally fabricated dewatering machine. The dewatered caked mash was broken into granules and spread out on a raised platform to sun-dry for 12 hr. The dry cassava granules were milled into powder using to produce cassava *fufu* flour. The *fufu* flour obtained was properly packaged and sealed in grip-seal polyethylene bags (GI-model, 2.25" x 2.25", jiffy bags macro packaging co., United Kingdom). Packaged samples were stored at room temperature ($28 \pm 2^{\circ}\text{C}$) until ready for analysis.

Preparation of Cooking Banana flour

Cooking banana flour was produced by the method adopted by (Udofiaet *al.*, 2010). Cooking bananas were cut into separate bunches which were subsequently defingered. The fingers were washed, peeled, cut into thin slices of about 2cm thick and blanched at 80°C for 5 min. Blanched plantain slices were drained and dried at 60°C for 24 h. The dried slices were milled

into flour in a local grinder to pass through a 250 micro metre aperture sieve and packed in a two-poly medium density (0.926-0.949) polyethylene.

Preparation of AYB flour

AYB flour was prepared by the method employed by (Aniedu and Aniedu, 2014). The seeds were thoroughly cleaned and sorted. Then 4kg of the clean seeds were fermented for 24 h and sun-dried until dried. The AYB were then dehulled separately using plate mill with clearance of 6mm between the plates. Then the cotyledons of AYB were milled into powder. Thereafter, the powders were sieved using muslin cloth (0.8mm screen size).

Proximate Analysis

The proximate composition of the processed flour composites was determined according to AOAC (1990).

Sensory Evaluation

The blended composite flours samples were reconstituted into paste by cooking 100 g of each of the samples with 3 parts of water while stirring vigorously for 5 minutes until it gelatinized and formed into suitable paste. A completely randomized block design was used to administer the samples in similar plates each with coded 3-digit non-misleading numbers to the panels. The dough samples were then presented to a panel of 20 untrained panelists who are cassava *fufu* consumers. The attributes assessed included appearance, taste, texture, and overall acceptability. These were scored using a 9 point- Hedonic scale which ranged from 1=like extremely to 9=dislike extremely, with 5= neither like nor dislike and the results analyzed amongst means compared using the ANOVA method and differences amongst means compared using the multiple F-test at 5% level of significance as described by (Iwe, 2002). The difference between the mean values was determined by Tukey's test.

Results and Discussion

Table 1 depicts the proximate composition of the flour samples. The moisture content of the composite flour blends ranged between 7.50% and 11.20%. The moisture content (11.20%) of the no. 3 control which contains 100% AYB was the highest, followed by the moisture content of sample no 9 (0, 33.3 and 66.7 %). The least moisture content (7.5 %) was observed in control 1 which contained 100 % CF flour. Moisture content above 14% indicates a danger of bacteria action and mould growth which results in short shelf life and development of hydrolytic rancidity in such flours (Ihekoronye and Ngoddy, 1985). Thus, all the moisture contents of the flour samples were within the safe limit.

Table 1: Proximate Composition of flour samples

S/N o	A	B	C	M/C (%)	Protein (%)	Fats (%)	Ash (%)	Fibre (%)	CHO (%)
1	1	0	0	7.50 ^e	1.96 ⁱ	0.50 ^e	0.46 ^f	0.59 ^e	88.90 ^a
2	0	1	0	8.30 ^d	2.89 ^g	0.70 ^e	2.58 ^a	2.30 ^d	81.73 ^b
3	0	0	1	11.20 ^a	19.53 ^a	4.91 ^a	1.92 ^c	2.78 ^a	59.66 ^g
4	0.667	0.333	0	7.70 ^e	2.90 ^h	0.60 ^e	1.70 ^d	0.95 ^e	86.15 ^a
5	0.667	0	0.333	9.40 ^c	9.10 ^e	3.40 ^b	1.25 ^e	2.00 ^c	74.80 ^{cd}
6	0.333	0.667	0	8.10 ^d	3.10 ^h	0.59 ^e	2.10 ^{bc}	1.20 ^d	84.51 ^{ab}
7	0.333	0	0.667	10.10 ^b	10.20 ^d	3.50 ^b	1.55 ^d	2.41 ^b	71.94 ^d
8	0	0.667	0.333	9.80 ^c	11.30 ^c	2.50 ^c	2.30 ^b	2.45 ^{bc}	71.70 ^d
9	0	0.333	0.667	10.20 ^b	15.40 ^b	3.60 ^b	1.95 ^c	2.55 ^c	65.95 ^e
10	0.333	0.333	0.334	10.10 ^b	8.32 ^f	2.10 ^d	1.75 ^d	2.150 ^d	75.48 ^c

A = cassava fufu flour, B = cooking banana flour and C = AYB flour.

S/No 1, 2, and 3 represent: 100 % cassava fufu (CF) (Control 1), 100 % cooking banana (CB) (Control 2), and =100% African Yam Bean (AYB) (Control 3) respectively.

The crude protein values (1.96 – 17.53 %), of the blended flour samples increased significantly ($p < 0.05$) with increase in AYB flour component of the mixture. The 100 % flour sample of AYB had the highest protein content of 17.53 %, while the mixture sample with 66.6 % AYB and 33.3% cooking banana flour had the second highest protein content. The least protein content was observed in control 1(100 % cassava *fufu* flour). Legumes are generally considered good sources of plant-based protein and are also recommended as healthy alternative to animal-derived foods because of their high protein content. The crude fat content ranged from 0.40 to 5.01%. The increase in AYB component of the mixture resulted to increase in crude fat. AYB flour (control 3) had the highest fat content (4.91 %), while the crude fat content of both CF and CB werethe least 0.50 and 0.70 %, respectively. The ash contents of the samples ranged from 0.46 to 2.58%. The 100 % cooking banana flour had the highest ash content (2.58 %) while 100% cassava *fufu* flour had the least ash content (0.46). The ash content of the mixture samples generally increased with increase in the cooking banana flour component of the mixture. Bananas are good sources of minerals especially potassium, a mineral involved in proper muscle contraction (Lehmann and Robin, 2007). The fibre contents varied from 0.59 to 2.78 % in the flour samples (Table 1). The AYB flour was the major contributor of fibre in the mixture, having the highest fibre content of 2.78 %, followed by flour mixture of sample 7 (33 % CB and 66.6 % AYB), while the least fibre content (0.59 %) came from control 1 (100 % CF flour). Fibres are important part of our diet; they in our meal speed up the passage of food in the gutwhich helpsin preventing constipation (FAO, 1998). The carbohydrate contents of the samples ranged from the least (55.66 %) in control 3 to the highest (88.90 %).in control 1. The second highest in carbohydrate content (86.15 %) was found in the mixed flours of sample 4 (66.6 % CF and 33.3 % CB). Thus, increasing AYB flour content in the mixture generally decreased the carbohydrate content of the blended flour samples. This could be attributed to relative low carbohydrate content of AYB flour when compared tocassava *fufu* flour and cooking banana.

Table 2 showed the mean scores of the sensory assessment of the reconstituted paste samples. The scores, in terms of appearance, ranged from 6.54 to 7.25. The paste from 100% cassava (control 1 or 2 or 3?) flour scored the highest (7.25) while the second highest score (6.96) for appearance was observed in samples numbers 4, 5, and 10. However, the score of appearance on the control sample was not significantly different ($p>0.05$) from samples numbers 4, 5, and 10. The paste made from 100% AYB flour had the least score (6.54) for appearance. Other scores for the samples mixtures on appearance were not significantly different ($p>0.05$). The scores for sensory texture ranged from 6.24 to 7.21 for the composite paste. The paste with the best sensory texture score (7.21) was produced from mixture sample number 9, followed by paste made from 100% AYB flour (control 3). However, the difference is statistically significant ($p<0.05$). The paste sample (66.6% CB and 33.3% AYB) scored the least (6.24), followed by the paste sample (66.7% cassava *fufu* and 33.3% cooking banana and 0% AYB) for the texture. Therefore, the textures of some of the mixtures were found to be more preferable than the texture of paste made from 100 % cassava *fufu* flour. The texture of foods has a substantial impact on consumers' perception of 'quality' (Fellows, 2000).

Table 2: Mean scores for sensory evaluation of pastes from flour samples

S/N	Appearance	Texture	Taste	Aroma	Gen Accept-ability
1	7.25 ^a ±0.65	6.79 ^{ab} ±0.75	7.21±0.85	6.96±0.86	7.43 ^a ±0.62
2	6.94 ^a ±0.63	6.83 ^{ab} ±0.76	6.83±0.94	6.63±0.86	6.94 ^{ab} ±0.67
3	6.54 ^b ±0.60	7.13 ^a ±0.65	6.67±0.85	6.79±0.84	7.42 ^a ±0.85
4	6.96 ^{ab} ±0.64	7.08 ^a ±0.86	6.58±0.85	6.54±0.94	7.42 ^a ±0.86
5	6.96 ^{ab} ±0.65	6.42 ^b ±0.67	6.54±0.94	6.83±0.86	6.92 ^{ab} ±0.66
6	6.79 ^{ab} ±0.74	6.75 ^{ab} ±0.68	6.71±0.94	6.21±0.87	6.50 ^b ±0.88
7	6.73 ^{ab} ±0.72	6.83 ^{ab} ±0.82	6.38±0.85	6.71±0.85	6.67 ^b ±0.87
8	6.86 ^{ab} ±0.68	6.24 ^b ±0.68	6.17±1.00	6.29±0.83	6.72 ^b ±0.78
9	6.67 ^{ab} ±0.58	7.21 ^a ±0.67	6.46±0.94	6.04±1.01	7.25 ^{ab} ±0.85
10	6.96 ^a ±0.68	7.08 ^a ±0.56	7.17±0.84	7.00±0.73	7.42 ^a ±0.65

Any two means followed by the same superscript letter for the same attribute in the same column are not significantly different at 5% significant level.

The sensory score for taste ranged from 6.84 to 7.00. The taste was rated 'good' on the average by the judges. However, the differences in sensory data for taste was not significantly different ($p>0.05$). This implies that the taste of the different paste samples were fairly the same irrespective of the variations in the component compositions of sample blends. The aroma scores for the varying component samples ranged from 6.21 in (33% CF, 66.7 CB and 0% AYB) to 7.00 in (33.3% CF, 33.3% CB, and 33.34 AYB). The scores represented by the panelists indicate that, on the average, the aroma was good. The differences in sensory data for aroma of the reconstituted paste samples were not statistically significant ($p>0.05$). Panelists were used to consuming traditionally processed cassava *fufu* which is odorous. This might be the reason

they for the general scoring of 'good' in all the mixture paste samples. The scores for general acceptability ranged from 6.50 to 7.43. There was no significant difference ($p>0.05$) between the general acceptability (7.43) of the control (100 % cassava *fufu*), and the general acceptability (7.42) of other three different component mixtures of the samples (100 % AYB; 66.6 % CF and 33.3 % CB; 33.3%, CF, 33.3 % CB, and 33.4 % AYB).

Conclusion and Recommendation

This study revealed that paste or *fufu* with improved nutrition, texture and aroma can be produced from blends of cassava *fufu*, cooking banana, and African yam bean composite flours. The moisture contents of all the samples were below 14 % which made them desirable. The overall protein content and fat content of the blended flour samples increased with increase in the AYB component of the mixture. The ash content of the blended flour samples generally increased with increase in the cooking banana flour component of the mixture. Increase in both cooking banana and AYB flours resulted to increase in overall fibre contents of the blended samples. The sensory evaluation indicated that sample number 10 scored higher than control 1 (100 % cassava *fufu*) in terms of texture, taste and aroma, though not significantly different ($p>0.05$). The general acceptability of the control 1 sample (100 % cassava *fufu*) was highest but not significantly different ($p>0.05$) from that of pastes from samples numbers 3, 4, 9 and 10. Sample number 10 which contained 33.3% CF, 33.3% CB, and 33.4 % AYB is hereby recommended as the most preferred sample. A further study on the glycemic index and texture profile analysis (TPA) of this work is highly recommended.

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FUNCTIONAL, AMYLOSE AND PASTING CHARACTERISTICS OF WHEAT, RICE AND WATER YAM COMPOSITE FLOUR BLENDS

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ABSTRACT

This study was carried out to investigate the influence of blending wheat (*Triticum aestivum*), rice (*Oryza sativa*) and water yam (*Dioscorea alata*) flours at different proportions on the functional and pasting characteristics of the composite flours. The proximate and amylose contents analysis was performed on the flour samples used for the study. The results showed that the crude protein (5.58-12.4%), amylose content (16.92 - 27.75 %), bulk density (0.77 - 0.93g/ml), gelatinization temperature (64 – 69 °C), and breakdown viscosity (34.27 - 88.12 RVU) varied significantly ($p < 0.05$) with change in the proportions of the blended flours. The local rice flour had the highest bulk density, gelatinization temperature, and breakdown viscosity, but had the least amylose content. These results showed that mixing the components of wheat, local rice, and water yam flour could be used to enhance the functional and pasting properties to suit their application in food and other industrial products.

INTRODUCTION

Composite flour is a mixture of different flours from roots and tubers, legumes, cereals or other raw materials that is created to satisfy specific functional characteristics and nutrient composition. FAO (1990) reported that the substitution of wheat flour with 20 percent non-wheat flour for the manufacture of bakery products would result in an estimated savings in foreign exchange of twenty million US dollars for developing countries of the world. No other crop for now is known to have the baking properties of wheat; hence composite flour has become the subject of numerous studies (Iwe *et al.*, 2016). Some other advantages of composite flour include improvement in the supply of proteins for human nutrition, and generation of income and support for rural development. In many Asian countries, rice flour has been used partially or fully to substitute wheat in noodles production (Makdoud and Rosentrater, 2017; Ahmed *et al.*, 2016; Ahmed *et al.*, 2015; Jeong-Ju and Suyong, 2014; Reungmanee-paitoon *et al.*, 2008). Water yam (*Dioscorea alata*) is a staple starchy food that is highly economical and desirable for the diabetic due to its low sugar content (Adeola *et al.*, 2017). Okeet *et al.* (2013), in his study, suggested that water yam has great potential as a food ingredient in extruded products and can be successfully used in the preparation of snacks, pre-gelatinized flours and breakfast cereals. Therefore, the aim of this study was to evaluate the functional, and pasting properties of blends of wheat-local rice-water yam composite flours.

MATERIALS AND METHODS

Raw material sources

Polished rice of FARO 44 variety used for this study was obtained from Abakaliki rice mill in Ebonyi State, Nigeria. The hard white wheat flour used was obtained from the Manager, Masters Energy Instant Noodles industry located in Uturu, Abia State, Nigeria. The tubers of water yam (*Dioscorea alata*) was obtained from the farm of National Root Crop Research Institute (NRCRI).

Raw Sample Preparation

Rice grains were cleaned, sorted and washed. They were then steeped in water for 12 h, drained and dried at 60°C in a hot air oven. Milling of the dried rice grains was done using attrition mill make and the milled grains sieved using a 300-µm mesh size sieve to obtain fine flour. Water yam tubers were washed with clean water to remove adhering soil and other undesirable materials. The tubers were thereafter hand-peeled, using kitchen knives and sliced into sizes of 2 to 3cm thickness. The yam slices were dried at 60°C in an oven. The dried yam slices was milled with a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, serial No. 950401) to pass through a 250 µm sieve (Endecotts Ltd, England) and packed in a high density polythene bag, stored at room temperature in a wood shelve in the Food Processing Laboratory, Food Technology department, Abia State Polytechnic Aba, until needed for analysis. The component proportions by volume of wheat, rice, and wateryam flours were measured in a measuring cylinder and introduced into the blender and the alkali mixture ingredients added in a blender, and thoroughly mixed.

Proximate Composition and Amylose Content: Proximate composition of the flour blends was determined using the AOAC (1990) method. Amylose content was determined by the rapid colorimetric method as described by Alexander and Griffiths (1993). Available carbohydrate was calculated by difference.

Functional properties: The loose bulk density, bulk density, carr index, water absorption capacity, oil absorption capacity, dispersibility, and gelatinization temperature were determined according to the method described by Onwuka (2018).

Pasting property: The method employed by Baek and Lee (2014) was used. A starch pasting cell attached to a controlled stress rheometer (AR1500ex, TA Instruments, USA) was used to investigate the pasting characteristics of composite sample flours in an aqueous slurry. The composite flours were suspended in distilled water (9.8%, w/w) and the suspension (28g) was subjected to the programmed heating-cooling cycle where temperature was held at 50°C for 1 min, raised to 95°C at a rate of 12°C/min, held for 2.5 min, cooled to 50°C at a rate of 12°C/min, and held for 2 min. Parameters that was determined are final viscosity, setback viscosity, pasting time and pasting temperature.

Raw Sample Preparation: Rice flour used production was prepared according to the method used by Iwe, *etal.* (2016). Rice grains were cleaned, sorted and washed. They were then steeped in water for 12 h, drained and dried at 60°C in a hot air oven. Milling of the dried rice grains was done using attrition mill make and the milled grains sieved using a 300-µm mesh size sieve to obtain fine flour. Water yam tubers were washed with clean water to remove adhering soil and other undesirable materials. The tubers were thereafter hand-peeled, using kitchen knives and sliced into sizes of 2 to 3cm thickness. The yam slices were dried at 60°C in an oven. The dried yam slices was milled with a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, serial No. 950401) to pass through a 250 µm sieve (Endecotts Ltd, England) and packed in a high density polythene bag, stored at room temperature in a wood shelve in the Food Processing Laboratory, Food Technology department, Abia State Polytechnic Aba, until needed for analysis. The component proportions by volume of wheat, rice, and water yam flours were measured in a measuring cylinder and introduced into the blender and the alkali mixture ingredients added in a blender, and thoroughly mixed.

RESULTS AND DISCUSSION

Proximate and Amylose Composition of local Rice, Water Yam, and Wheat Flours.

The proximate composition and amylose content of the flour samples were presented in Table 1. These analyses were performed on the flour samples to establish the characteristics of the raw materials flour samples used in this study. All the parameters from moisture to amylose contents varied significantly ($p < 0.05$) (Table 1). The local rice flour had the highest moisture content (12.10 %) while the industrially produced wheat flour used had the least moisture content of 5.58 %. However, the moisture content of rice and water yam flours were not significantly different ($p > 0.05$). The relative high moisture contents of rice and water yam flours might be due to soaking before drying of the raw samples of rice. Low moisture content favours long shelf life, while higher moisture content shortens the shelf life of a product through encouraging microbial growth which causes spoilage of the product

Table 1. Proximate composition and amylose contents of composite flour samples

Samples	M.C (%)	Crude Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	Amylose
RICE	12.10 ^a ±0.42	10.08 ^b ±0.32	1.58 ^a ±0.06	1.04 ^b ±0.08	1.38 ^b ±0.04	72.63 ^b ±1.05	16.92 ^c ±0.54
WYAM	11.57 ^a ±0.19	5.82 ^c ±0.25	1.49 ^{ab} ±0.11	2.23 ^a ±0.11	1.75 ^a ±0.07	78.03 ^a ±0.62	22.03 ^b ±0.33
WHEAT	5.58 ^b ±0.11	12.40 ^a ±0.28	1.27 ^b ±0.04	1.23 ^b ±0.01	0.52 ^c ±0.01	78.71 ^a ±1.13	27.75 ^a ±0.35
LSD	5.99	1.72	0.31	1.00	0.38	5.40	5.11

Any two means having differences greater than LSD (5%) are significantly different.

The wheat flour had the highest protein content of 12.40 %, followed by the protein content of rice flour (10.08 %), while the water yam flour had the least protein content (5.58 %). The protein content of rice flour falls within the range expected for the variety (faro 44) (Odenigboet *al.*, 2014). The protein content of water yam flour is in agreement with the protein content of the water yam variety (*D alataHingurala*) reported by Senanayakeet *al.* (2012), while the protein content (12.40 %) of wheat falls within the range expected of wheat grains used for preparation of noodles (Guliaet *al.*, 2014). The relative high protein in wheat is due to the presence of gluten which is the protein responsible for the visco-elastic characteristics of dough made from wheat.

The fat contents were generally low. The rice flour had the highest level of fat content (1.58 %), while the least fat content of 1.27 % was observed in wheat flour. The low-fat levels are preferable for long shelf life, because all fats and fat containing foods containsome unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity(Iweetal., 2016).

The water yam flour had the highest ash content (2.23 %) that was significantly higher than that of rice (1.04 %) and that of wheat (1.23 %). Ash However, the ash contents of both rice and wheat flour were not significantly different. Determination of ash content is widely used in the flour milling industry as a quality measure for flour extraction. Too high ash in flour may indicate too much contamination of flour with bran (Nielson, 2003).

The fibre contents of the flours are significantly different ($p < 0.05$). Water yam flour had the highest (1.75 %), followed by that of rice (1.38 %), while the wheat flour had the least fibre content of 0.52.

The carbohydrate contents of water yam and wheat flours were 78.08 % and 78.71 % respectively with no significant difference ($p > 0.05$). Rice flour had the least carbohydrate content of 72.63 %.

Wheat flour had the highest amylose content of 27.75 %, followed by water yam flour with amylose content of 22.03 %, while the rice flour had the least amylose content of 16.92. An amylose content can be classified as waxy (0-2%), low (10-20%), intermediate (20-25%) and high (>25) amylose content (Chatterjee and Das, 2018). Thus, based on this classification, the rice used for this study can be classified as low. High amylose content (>25 g/100 g) in rice used for noodle production plays a critical role in creating a gel network and sets the noodle structure (Fariet *al.*, 2011). The amount of amylose present in the starch granule has significant effects on the starch physicochemical and functional properties. Amylose has been reported to play a role in the initial resistance of granules to swelling and solubility, as swelling proceeds rapidly after leaching of amylose molecules. Also the capacity of amylose molecules to form lipid complexes prevents their leaching and consequently the swelling capacity (Alcázar-Alay and Meireles, 2015). This implies that higher amylose content in starch may reduce breakdown viscosity in starch and cooking loss in noodles.

Table 2. Functional Properties of blended Flour Samples

Samples	LBD (g/ml)	TBD (g/ml)	Carr index (%)	WAC (ml/g)	OAC (ml/g)	Dispersibility (%)	G.T. (°C)
100% W	0.57±0.06	0.78 ^b ±0.03	28 ^a ±0.02	2.15±0.50	1.85 ^b ±0.15	75.00 ^a ±6.50	52.5 ^a ±2.12
100% R	0.70±0.03	0.82 ^a ±0.03	15 ^b ±0.02	1.90±0.20	2.99 ^a ±0.10	59.00 ^c ±4.50	60.0 ^{bcd} ±1.41
100%Y	0.60±0.02	0.77 ^b ±0.07	22 ^a ±0.00	2.10±0.40	1.76 ^b ±0.20	70.50 ^{ab} ±3.50	65.5 ^{ab} ±2.12
W:R (50:50)	0.63±0.00	0.85 ^a ±0.00	20 ^a ±0.01	2.10±0.45	1.93 ^b ±0.04	71.00 ^{ab} ±4.50	54.0 ^d ±2.82
R:Y (50:50)	0.69±0.01	0.93 ^a ±0.02	26 ^a ±0.00	1.95±0.20	1.85 ^b ±0.10	69.50 ^{ab} ±4.00	69.0 ^a ±2.4
W:Y (50:50)	0.58±0.06	0.79 ^b ±0.03	26 ^a ±0.01	2.12±0.50	1.78 ^b ±0.20	71.50 ^{ab} ±4.00	62.0 ^{abc} ±2.3
WRY(66.6:16.7:16.7)	0.70±0.08	0.87 ^a ±0.07	21 ^a ±0.02	1.90±0.30	1.37 ^c ±0.10	73.50 ^a ±2.5	55.0 ^{cd} ±1.2
RWY(66.7:16.7:16.7)	0.70±0.07	0.89 ^a ±0.01	21 ^a ±0.01	1.80±0.20	1.94 ^b ±0.25	65.00 ^b ±5.0	61.5 ^{bc} ±2.12
LSD:	NS	0.15	0.11	NS	0.08	5.5	7.5

W = Wheat flour, R = Rice flour, Y = Water yam flour. NS = Not significant at 5% significant level. Means in the same column with different superscripts are significantly different. G.T. = gelatinization temperature

Functional Properties of Blended Flours

Tables 2 below depicts some functional properties of the rice flour (faro 44 rice), water yam flour, and wheat flour samples. Functional properties can be defined as the characteristics which govern the behavior of nutrients in food during processing, storage, and preparation as they affect food quality and acceptability (Onwuka, 2018).

The loose bulk densities (LBDs) were not statistically different ($p>0.05$). The tapped bulk density (TBD) of the flour samples were significantly different ($p<0.05$). Among the pure samples (not blended), the 100 % rice flour had the highest bulk density of 0.82 g/ml and was consistent with the values of bulk density on local rice flour reported by Iwe (2016). Blending of flours did not significantly affect the bulk densities of the flour samples as indicated in Table 2 Low bulk density is desirable in infant feeding (Omeire *et al.* 2014), which also reduces storage and transportation cost. The carr index of the blended flour samples ranged from 15 to 28 % and were statistically different ($p<0.05$). Flour sample 100 % W had the highest carr index of 28 %, while the flour with the least carr index (15 %) is sample (100 % R). The carr index is used to measure the compressibility of powder, and is often applied in pharmaceuticals as an indication of flowability of powder. Flour that has carr index greater than 25 is rated 'poor flowability', while the one below 15 is rated 'good flowability' (Onwuka, 2018). Thus sample 100 % W used for this study has poor flowability, while the 100 % rice flour has fairly good flowability. Blending of flours did not significantly ($p>0.05$) affect the flowability of the flour-samples..

WACs capacities of the flour samples are not statistically different ($p>0.05$). The oil absorption capacities (OACs) of the flour samples were significantly different ($p<0.05$). Sample 100 % R had the highest OAC of 2.99 ml/g and is significantly different from OACS of samples 100 % W and 100 % Y. However, the OACs of 100 % W (1.85 ml/g) and that of 100 % Y (1.76

ml/g) were not significantly different ($p>0.05$) (Table 2.). Sample WRY (67.7:16.7:16.7) had the least OAC of 1.30 ml/g. Flours ability to absorb and retain oil may help to improve binding of the structure, enhance flavour retention, and improve the mouthfeel (Aboshora *et al.*, 2014).

The percentage dispersibility ranged from 59 to 75 %, and were significantly different ($p<0.05$). The 100 % wheat flour had the highest dispersibility, while 100 % local rice flour had the least dispersibility of 59 %. Blending of wheat flour with either rice and/or water yam flour as seen in the flour sample mixture RWY (66.7:16.7:16.7) reduced the dispersibility significantly ($p<0.05$). Dispersibility is used to indicate the reconstitutability of flours or blends in water (Sanni and Ajakaye, 2007). Thus, the 100 % wheat flour which had the highest dispersibility will reconstitute better in water than the rice and water yam flours.

Gelatinization temperatures (GTs) for wheat, local rice, and water yam flours were 52.50, 60.00, and 65.5°C respectively, and were significantly different ($p<0.05$) from each other. GT is also associated with cooking time of starchy products. Rice cultivar with low gelatinization temperature coupled with high amylose content is suitable for making rice noodles (Cham and Suwannaporn, 2010).

Pasting property

The results from the pasting characteristics of wheat, local rice, and water yam flour samples and blends were significantly different ($p<0.05$). This implies that mixing of the flour samples can be used to achieve a characteristic suitable for their application in industrial food products.

CONCLUSION AND RECOMMENDATION

The study showed that blending of different proportions of wheat, local rice and water yam significantly ($p<0.05$) affected the functional (Table 1), proximate, and pasting characteristics of the flour mixture. The functional and pasting properties affect quality and acceptability as they govern the behaviour of nutrients in food during processing, storage, and preparation. Thus, the mixing of the components of wheat, local rice, and water yam flour could be used to enhance the functional and pasting properties to suit their application in food and other industrial products.

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**PROXIMATE AND SENSORY EVALUATION OF BISCUIT PRODUCED
FROM WHEAT (*Triticumaestivum L*) AND POTATO (*Solanumtuberosum*)
FLOUR BLENDS**

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ABSTRACT

Biscuits are prominent ready-to-eat baked snack usually produced from wheat flour. This study was carried out to evaluate the quality of biscuits produced from wheat and potato flour blends. Five blends of wheat: potato flours in the ratio of 100:0, 90:10, 80:20, 70:30 and 60:40 were formulated and used to produce biscuit. The flour and biscuit were evaluated for proximate composition and sensory quality attributes using standard methods. Results of proximate composition of the flour blends showed that protein, ash, fibre and moisture contents increased significantly ($p < 0.05$) from 10.50 to 11.25 %, 1.28 to 2.76 %, 3.20 to 4.21 % and 8.58 to 9.23% respectively while fats and carbohydrate decreased from 1.90 to 1.20 % and 74.54 to 71.46 % as the level of potato flour increased. Findings from sensory evaluation revealed that biscuit from 60 % wheat and 40 % potato ranked highest in terms of colour, aroma, taste and overall acceptability. This study therefore established that the inclusion of potato flour to wheat flour significantly improved proximate composition and also improved the sensory attributes of biscuit.

INTRODUCTION

Biscuit is an important edible confectionary crisp product of wheat majorly consumed with tea by humans especially children and it is sometimes used as weaning food for infants (Ferial and Azza, 2011). Biscuits are convenient ready-to-eat baked snack consumed by all age groups in many countries (Adebowale *et al.*, 2012; Arise *et al.* 2016). Wheat with other ingredients such as egg, fat, sugar, water, sweeteners as well as sensory quality improvers for example vanilla, are the main ingredients for the production of conventional biscuits (Adebowale *et al.*, 2012; Uchenna and Omolayo, 2017). Biscuit is an essential food material that contributes valuable quantities of 20 ppm iron, 12 ppm calcium, 100 ppm protein, 20 ppm calories, 40 ppm fibre per 100 g and also some of the B-vitamins to our diet and daily food requirement (Barca de laet *al.*, 2010).

Wheat is a major cereal crop in many parts of the world. Most of the wheat produced is used for human consumption and because of its unique properties, a large range of ingredients and foods are produced, including wheat germ, couscous, cracked wheat and wheat starch (Slavin, 2003). Wheat as the major raw material in pastry and bakery industries is rarely grown in Nigeria and is very expensive to import (Oyeyinka, *et al.* 2014). This has consequently increased

the cost of biscuit production. Reports from International Institute for Tropical Agriculture (IITA) revealed that importation of wheat into Nigeria amount to the tons of N40.7 billion, hence there is need to develop some strategies such as the use of composites to mitigate the situation. Composite flour is a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour (Arise *et al.*, 2016; Juliantiet *al.*, 2017). Arise *et al.* (2016) had reported that composite flour utilization in the production of pastry and bakery products reduced the need for importation of wheat flour and has brought about the use of underutilized indigenous crops through value addition. Successful efforts had been made in the use of composite flour from different crops in the production of bread and baked products (Adebowale *et al.*, 2012; Adeola and Ohizua, 2018).

Potato (*Solanumtuberosum*), is the most cultivated non-cereal crop in the world, ranking fourth after rice, wheat and corn (FAOSTAT, 2019), it has been identified to be the fourth most important root crop in Nigeria, after cassava, yam and cocoyam (Okonkwo *et al.*, 2009). Potato represents an important component of human diet, because the tubers are able to supply several nutrients, such as essential amino acids, vitamins (as vitamin C) and minerals (Melito *et al.*, 2017). The protein/carbohydrate ratio is higher than for most cereals and even higher than those of the other tuber and root crops (Okonkwo *et al.*, 2009). The tubers have been consumed in various forms in developing countries of Africa, including eating in cooked form, incorporation with yam during pounded yam preparation and processing into flours along with yams for edible dough such as amala in Nigeria (Ikeyi, 2013). Due to the high cost of importation of wheat, and the directives from the Federal Government of Nigeria to add 10 % cassava flour in wheat flour for food products, several research had been tailored towards the effects of complementing wheat with cassava. Similarly, Oyeyinka *et al.* (2014) and Arise *et al.* (2017) demonstrated the effect of plantain flour on biscuit production, however, little or no information on the performance of potato with all its nutritional and sensory benefits is available on the production of biscuit. Thus, this study therefore seeks to reduce the cost of importation of wheat through the utilization of potato and to evaluate the effect of potato flour inclusion on the nutritional and sensory qualities of biscuit.

MATERIALS AND METHODS

Source of materials

Potato tubers were purchased from Wednesday market in Dutsin-Ma Local Government Area of Katsina State, Nigeria. Dangote wheat flour, salt and sugar were obtained from Alhaji Bilya supermarket in Dutsin-Ma Local Government Area of Katsina State, Nigeria. Also fats (Monita), baking powder (Baker's choice) and vanilla flavour used were all purchased in the aforementioned supermarket.

Preparation of potato flour

The potato tubers were peeled, dipped in water with 0.25% Sodium bisulfite, and were thoroughly washed, sliced to 3mm thickness and then dried in a thermo-regulated oven

(Gallenkamp, BS model 0v-160, Switzerland) at 65°C for 4h. The dried potato chips was milled with hammer mill into flour and then sieved with 250µm particle size sieve. The flour was then sealed in Ziploc cellophane bag and stored at 33°C room temperature until it was needed for blend formulation as described by (Okaka, 2005).

Formulation of composite flour

Five composite blends of wheat and potato flours were formulated in the ratios of 100:0, 90:10, 80:20, 70:30 and 60:40. The flour blends were thoroughly mixed to obtain homogeneous blends and were stored in airtight containers at 33°C room temperature until when needed for biscuit production.

Biscuit production

The biscuit samples were prepared using the method described by Oyeyinka *et al.* (2014). Sugar (150g), baking fat (190g) and salt (5g) were mixed together manually in a bowl. Flour blends (500g) were mixed with baking powder (2.5g) and vanilla (5g) were added and thoroughly mixed into batter. Water (125ml) was gradually added to form slightly firm dough. The dough was kneaded, shaped using the stamp cutter and baked on a greased tray in an oven (Gallenkamp, BS model 0v-160, Switzerland) at 180°C for 20 minutes.

Determination of proximate composition of wheat-potato flour blend

Proximate analysis was carried out on the wheat-potato flour blends to determine the moisture, ash, crude fiber, fat, protein and carbohydrate content using the method described by AOAC, 2010.

Sensory analysis of wheat-potato flour biscuit

This was done to determine the consumers' preference for wheat-potato biscuit using the method of Iwe (2002). A total of thirty (30) semi-trained panelists were assembled to assess the biscuit samples for taste, colour, aroma, mouth feel and general acceptability using a 9-point hedonic scale.

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) using Statistical Package for the Social Sciences, SPSS version 23.0 software and the means were compared using Duncan Multiple Comparison test.

RESULTS AND DISCUSSIONS

Proximate composition of wheat-potato flour blend

Table 1 shows the result of the proximate composition of wheat and potato flour blends. There was significant difference ($p < 0.05$) in protein, fibre, moisture and ash with a corresponding decrease in fats and carbohydrates. Protein is essential for human production and proper body maintenance including growth, repair and maintenance of the body. The mean protein content ranged from 10.50% in the control (100 % wheat flour) to 11.25% in sample with 40 % potato flour. Results showed that protein content increased significantly ($p < 0.05$) with increase in the inclusion of potato flour. Effiong *et al.* (2009) stated that any plant foods that provide about 12 % of the calorie value from protein are considered good sources of protein. The protein contents from all the samples were close to the 12 %, however, further processing of the flour into biscuits or other products with the addition of other ingredients could help to achieve the desired amount of protein. Also, the consumption of the biscuit made from these flours with other nutritious foods could help the protein up. However, flour sample with 60 % wheat and 40 % potato was the highest and values from this research revealed that supplementation with potato flour can improve the protein content of the composite flour.

The fat content among flour samples decreased from 1.90 % to 1.20% with increase in the level of potato flour supplementation. This is an indication that wheat has more fat than potato. Fat can influence the shelf life of food products such as baked foods. Fat also contribute substantially to the energy value of foods and low fats may be beneficial to those that suffer from atherosclerosis and related health issues (Eleazu and Ironua, 2013). Conversely, fats add to the ability to retain flavour and palatability of foods. The fat contents in all the samples analysed are quite low and may not predispose the flour to rancidity or expose consumers to any health challenges and hence could be recommended for weight watchers.

Fibre is an indigestible component of plant material that helps in improving roughage and bulk as well as contributes to a healthy condition of the intestine. Fibre increases stool bulk and decreases the time that waste materials spend on in the gastro intestinal track. Fibre helps in the maintenance of human health and has been known to reduce cholesterol level in the body Bello *et al.* (2008). The fibre content from this research increased with the level of supplementation with potato flour, the highest mean value (4.21%) was observed in sample with 40 % potato flour while the least value (3.20 %) was in 100 % wheat flour. There was significant difference ($p < 0.05$) among the samples. The results indicate that potato flour has more fibre than wheat flour. This could be attributed to the over processing of wheat to get a fine flour and this was in agreement with the reports of Onabanjo and Ighere (2014) for wheat flour supplemented with potato.

Moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination. The moisture contents in flour blend

samples of 100:0, 90:10, 80:20, 70:30 and 60:40 ranged from 8.58 to 9.23 %, and 100 % wheat flour had the least value, while sample with 40 % potato flour inclusion had the highest mean value. There was significant difference among sample at ($p < 0.05$). The result is in agreement with the work of (Onabanjo and Ighere 2014; Khalduzzma *et al.*, 2010). However, the result of moisture contents from this study is an indication that the flour blends would have good storage stability if properly packaged.

The ash content of food material is an index of mineral constituents of the food because ash is the organic residue remaining after water and organic matter have been removed by heating in the presence of an oxidizing agent (Sanniet *et al.*, 2008). Sample with 100 % wheat flour had the least mean value of ash content (1.28%) while Sample with 40 % potato flour had the highest mean value (2.76%). There was significant difference among all the samples at ($p < 0.05$). Results from the study revealed that ash content increased with increase in level of substitution of wheat with potato flour, indicating that potato is denser than wheat in minerals. Higher ash content indicates a higher mineral content which implies that individual feeding on the flour blends will not be mineral deficient.

The carbohydrate contents ranged from 74.54 to 71.46 %, the highest mean value was recorded in the control (100 % wheat flour) while sample with 40 % potato flour inclusion had the least carbohydrate contents. There was significant difference ($p < 0.05$) among samples, the results however showed decrease in carbohydrate with increase in the level of potato flour inclusion.

Table 1: Proximate Compositions of Wheat- potato Flour Blends

Treat-ments	Protein(%)	Fat(%)	Fibre(%)	Mois-ture(%)	Ash(%)	Carbohy-drate(%)
100:0	10.50±0.00 ^c	1.90±0.21 ^a	3.20±0.03 ^d	8.58±0.04 ^d	1.28±0.04 ^e	74.54±0.54 ^a
90:10	10.65±0.10 ^b	1.80±0.17 ^a	3.42±0.00 ^c	8.65±0.07 ^c	1.58±0.03 ^c	73.90±0.21 ^b
80:20	10.75±0.00 ^b	1.60±0.01 ^b	3.52±0.03 ^b	8.70±0.04 ^{bc}	1.50±0.00 ^d	73.93±1.04 ^b
70:30	10.85±0.35 ^{ab}	1.40±0.27 ^b	4.11±0.16 ^a	8.75±0.07 ^b	2.53±0.04 ^b	72.36±0.38 ^c
60:40	11.20±0.00 ^a	1.20±0.13 ^c	4.21±0.01 ^a	9.23±0.11 ^a	2.76±0.00 ^a	71.46±1.24 ^c

Values are means ± standard deviation of duplicate determination; Means with different superscript in the same column are significantly different at $p < 0.05$

Sensory attributes of wheat-potato flour biscuit

Result of the sensory analysis of biscuits produced from wheat-potato flour blends of 100:00, 90:10, 80:20, 70:30 and 60:40, is as presented in Table 2 for taste, colour, aroma, mouth feel and general acceptability. It was observed that the inclusion of potato, improved the colour of the biscuit, as sample with 40% potato blend had the most acceptable colour with mean value of 7.50 while the control (100%) had the least mean value of 6.95. There was however, signif-

ificant difference ($p < 0.05$) among samples with improvement in colour as the level of incorporation increased. Aroma is a fundamental sensory attribute which denotes the sensation in the nostrils as a rising of food or drink volatile compounds. Sample with 40 % incorporation had the highest mean value of 7.35 while that with 10 % potato flour had the least mean value of 6.75. However, there was no significant different ($p < 0.05$) between samples C and D. In any case, supplementation with potato improved the aroma.

Mouth feel is the response of the sense organs to the level of roughness, smoothness, chew ability, stickiness of food in the mouth. Biscuit produced with 10 % potato flour had the highest mean value of 7.95, while those with 20%, 30% and 40% of potato substitutions had 7.05, 7.15, and 7.20 respectively. The result showed that biscuit sample with 10 % potato flour was ranked highest by the panelists. Taste is a code denoted to different foods by the sensational palate when the food is ingested into the mouth. Samples with 20%, 30% and 40% potato flour inclusion had the highest taste quality with mean value of 7.10. However, there was significant difference ($p < 0.05$) among other flour blends and the control (100 % wheat flour) which has the least taste score of 6.95. Result showed that increase in supplementation improved the taste of the biscuits. In summary, sample with 40 % potato blend had the highest mean score for general acceptability with a mean value of 7.45 while the control had the least score of 7.00. There was significant difference ($p < 0.05$) among the samples. The results showed an increasing trend in the level of general acceptability with increase in the level of potato flour.

Table 2: Sensory Evaluation of Wheat-Potato Composite Flour Biscuits

Treatments	Colour	Aroma	Mouth feel	Taste	General Acceptability
100:0	6.95±0.76 ^a	6.20±1.28 ^b	7.85±1.09 ^a	6.95±0.02 ^b	7.00±0.14 ^c
90:10	7.05±1.00 ^a	6.75±1.25 ^{ab}	7.95±1.15 ^a	7.00±0.04 ^b	7.10±0.02 ^c
80:20	7.10±1.45 ^a	6.85±0.81 ^a	7.05±1.15 ^a	7.10±0.02 ^a	7.15±0.05 ^b
70:30	7.40±1.27 ^a	7.20±1.57 ^a	7.15±0.88 ^a	7.10±0.04 ^a	7.20±0.24 ^b
60:40	7.50±0.89 ^a	7.35±0.75 ^b	7.20±1.15 ^a	7.10±0.03 ^a	7.45±0.09 ^a

Values are means ± standard deviation of duplicate determination; Means with different superscript in the same column are significantly different at $p < 0.05$

CONCLUSION

This research work has shown that supplementation of wheat flour with potato flour significantly improve the nutritional composition of the flour as it yields higher percentages of protein, lipids, fibre and ash contents. There is also improvement in the sensory quality attributes of wheat-potato biscuits in terms of colour, aroma, taste and overall acceptability and biscuit samples with 60 % wheat and 40 % potato blend was the most preferred.

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FUNCTIONAL AND PHYSICAL PROPERTIES OF FLOURS AND COOKIES PRODUCED FROM BLENDS OF WHEAT, TIGERNUT AND ORANGE-FLESHED SWEET POTATO

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Abstract

Cookies are nutritious ready-to-eat baked snacks available in different sizes and shapes. This study investigated the functional properties of flours and physical properties of cookies from wheat, tiger nut and orange-fleshed sweet potato (OFSP) flour blends. Wheat flour (WF) was substituted with tiger nut and OFSP flours and formulated into six different ratios (85:10:5, 80:10:10, 75:10:15, 70:10:20, 65:10:25, 60:10:30), while 100Wf serves as the control. The result of the functional properties ranged from 0.73-0.85 g/cm³, 1.81-2.48 g/ml, 1.92-2.85 g/ml, 72.00-74.00°C, 1.35-7.18min/sec and 32.33-52.21% for bulk density, water absorption capacity, oil absorption capacity, gelatinization temperature, wettability and emulsion capacity, respectively. The result of the functional properties showed no significant difference ($p>0.05$) in the bulk density and gelatinization temperature of the flour blends. The physical properties of the cookies also exhibited no significant differences ($p>0.05$) in the thickness, spread ratio and volume of the cookies. However, there were significant differences ($p<0.05$) in the weight, diameter, density and breaking strength of the cookies. It was concluded that inclusion of tiger nut and increased proportion of orange fleshed sweet potato enhanced the weight, density and breaking strength of the cookies.

Key words: Orange-fleshed sweet potato, Tiger nut, Functional Properties, Physical Properties, Cookies

Introduction

Cookies are one of the most common baked snacks consumed among all age groups in many countries due to their creamy taste and low water activity which defines their long shelf life (Chauhan *et al.*, 2016).

Wheat (*Triticum aestivum*) flour is the most versatile and principal raw material utilized in the production of baked foods however, its cultivation is limited in some parts of the world due to the climatic conditions hence, has necessitated its importation in those parts of the world (Dambazau *et al.*, 2021).

Sweet potato (*Ipomoea batatas*) is a vital staple crop that serves as an important food crop of major economic importance in the tropical regions where it is grown (Vimala, 2011). The orange-fleshed sweet potato contains significant amounts of carotenoids which underlines its role in the mitigation of VAD in developing countries (Satheesh and Workneh, 2019).

Tiger nut (*Cyperus esculentus*) on the other hand is a lesser known and underutilized crops potentially valuable as human and animal food which has been identified to maintain a balance

between population growth and agricultural productivity particularly in the tropical and sub-tropical areas of the world (Adejuyitan, 2011).

The addition of different proportions of tigernut and orange-fleshed sweet potato flours in wheat flour may modify the functional properties of the composite blends and the physical properties of cookies prepared from the blends.

2.0 Materials and Methods

2.1 Source of raw materials

The wheat, tiger nut and all other baking ingredients used for the production of the cookies were purchased from Umuahia Main Market. The orange-fleshed sweet potato tubers were procured from National Root Crops Research Institute (NRCRI), Umudike, all in Abia State, Nigeria.

2.2 Production of flours

In the production of wheat flour, the method described by Ndife *et al.* (2014) was adopted. The wheat kernels were sorted, washed in clean water and steeped (4 h) in water (2:1). The wheat was drained off water using a perforated plastic container, dried (60°C, 6 h) in a Uniscope laboratory hot air drying oven (model SM9023) and milled into flour with an attrition mill (model SK-30-SS, place of manufacture?). The resultant flour was sieved through a 0.4 mm sieve mesh and packaged in an airtight plastic container until needed.

The method described by Adejuyitan *et al.* (2009) was adopted for the production of tiger nut flour. The tiger nut seeds were sorted, cleaned, washed in clean water, drained off water using a perforated plastic bowl, oven dried (60°C, 3 h) using Uniscope laboratory hot air drying oven (model SM9023) and milled into flour with an attrition mill (model SK-30-SS). The resultant flour was sieved through a 0.4 mm sieve mesh and packaged in an airtight plastic container until needed.

The method described by Singh *et al.* (2008) was used in the production of orange sweet potato flour. The wholesome orange fleshed sweet potato tubers were sorted, washed, peeled and sliced into 1-1.5mm thickness with stainless kitchen knife, blanched in boiling water for 2 min, drained off hot water using metallic perforated bowl and oven dried (60°C, 24 h) in Uniscope laboratory hot air drying oven (model SM9023). The dried potato slices were milled into flour with an attrition mill (model SK-30-SS) and subsequently sieved through a 0.4 mm sieve mesh and packaged in an airtight plastic container until needed.

2.3 Formulation of flour blends

Wheat, tiger nut and orange fleshed sweet potato flours were blended to obtain six (6) composite flour; 85Wf10Tn5Sp; 80Wf10Tn10Sp; 75Wf10Tn15Sp; 70Wf10Tn20Sp; 65Wf10Tn25Sp; 60Wf10Tn30Sp while 100Wf serves as the control. Where; Wf = wheat flour; Tn = tiger nut flour; Sp = orange fleshed sweet potato flour.

2.4 Production of cookies

In the production of cookies, the method described by Ayo *et al.* (2018) was used. The fat (200 g) and sugar (150 g) were creamed to a smooth consistency; egg (125 ml), water (75 ml), salt (2.5 g), and milk flavor (5 ml), were added and mixed until homogeneous mixture was ob-

tained. The dry ingredients; flour(500 g), baking powder (5 g), nut meg (5 g) were mixed together and added to the cream followed by mixing to form dough. The dough was kneaded to uniform thickness, rolled out thinly on a flat table and cut into desired sizes and shapes of 6 cm diameter with biscuit cutter. They were placed in greased baking trays and baked (190°C, 20 min). The hot baked biscuits were allowed to cool, packaged in hermetically sealed plastic container and stored at room temperature until needed.

Determination of functional and physical properties

The flour blends were analysed for the following functional properties; bulk density, water/oil absorption capacity, gelatinization temperature, wettability and emulsion capacity using the methods described by Onwuka (2018).

The weight, diameter and thickness were determined according to the methods described by Ayo *et al.* (2007). The spread ratio, volume and break strength were determined according to the method described by Bala *et al.* (2015).

The data obtained was subjected to analysis of variance of a completely randomized design using Statistical Package for the Social Sciences (SPSS) version 21.0 for personal computer while treatment means were separated using Duncan's multiple range test at 95% confidence level ($p < 0.05$).

3.0 Results and Discussion

3.1 Functional properties of flour blends

The functional properties of the flour blends are presented in Table 1.

There was no significant difference ($p > 0.05$) in the bulk density amongst all the flour samples. Values recorded for bulk density ranged from 0.73-0.85 g/cm³ and was similar to the values (0.762 – 0.820g/cm³) reported by Chandra *et al.* (2015) for bulk density of composite flour produced from wheat, rice, green gram and potato flours. The water and oil absorption capacities were observed to be higher the flour composite compared to the control sample and increased as the proportion of OFSP increased. This is an indication that OFSP has the capacity to absorb water and oil compared to the control (100% wheat). Interestingly, the results showed no variation in the gelatinization temperature of the flour samples. However, values (72.00 – 74.00°C) recorded for gelatinization temperature of the composite flours in this study were higher than that recoded by Chandra *et al.* (2015) for composite flour produced from wheat, rice, green gram and potato flours. The wettability of the flour blends ranged from 1.35-4.18 min/sec for samples 75Wf10Tn15Sp and 100Wf (control). The implication is that samples with low wettability would be dispersed so easily in water than the other samples. The emulsion capacity increased with increased proportion of OFSP. The range of values (32.33-52.21g/ml) for emulsion capacity obtained in this study was significantly higher than values (10.05-18.86g/ml) recorded by Ajani *et al.* (2016) for composite flour produced from wheat and breadfruit.

3.2 Physical properties of cookies

The results of the physical properties of the cookies are presented in Table 2. The results showed no significant differences ($p > 0.05$) amongst the cookies samples in terms of thickness, spread ratio and volume. The weight of the cookies ranged from 4.27(100% wheat flour)-7.82g (60Wf10Tn30Sp). All the cookies samples from the composite flours had higher weights

than the control (100% wheat flour). This could be related to the higher bulk densities of the samples with flour blends of tiger nut and orange fleshed sweet potato which have been shown to increase weight of baked foods (Awuchi et al., 2019). Sample 70Wf10Tn20Sp had the highest diameter (3.57cm) but was not significantly different from the control sample (100Wf). The result revealed no significant differences in the thickness, spread ratio and volume of the cookies. The density values ranged from 0.70 to 1.32 g/cm³ with the control sample recording the lowest value while cookies sample while 60Wf10Tn30Sp had the highest. Similar results were reported by Jemziya and Mahendran (2017) for the density of cookies produced from composite flours made from sweet potatoes and wheat flour. Breaking strength values of the cookies increased from 25-40% replacement of wheat flour with tigernut and orange fleshed sweet potato flours.

4. Conclusions

This study has shown that the addition of 10% tiger nut and increase in the proportion of orange fleshed sweet potato flour for up to 30% enhanced the functional properties (bulk density, water/oil absorption capacity and emulsion capacity) of the flour blends. This study also revealed that substitution of wheat with tiger nut and orange fleshed sweet potato enhanced the density and breaking strength of the cookies. It is therefore, recommended that cookies with high density and breaking strength could be produced from flour blends of 10% tiger nut and 30% orange fleshed sweet potato.

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Table 1: Functional properties of wheat, tiger nut and orange fleshed sweet potato flour blends

Sample code	Bulk density (g/cm ³)	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Gelatinization temperature (°C)	Wettability (min/sec)	Emulsion capacity (%)
100Wf(control)	0.73 ^a ±0.04	1.81 ^a ±0.01	1.92 ^a ±0.03	72.50 ^a ±3.54	4.18 ^a ±0.01	32.33 ^a ±0.04
85Wf10Tn5Sp	0.75 ^a ±0.00	1.88 ^a ±0.01	1.97 ^a ±0.01	72.50 ^a ±3.54	3.22 ^a ±0.01	41.42 ^a ±0.02
80Wf10Tn10Sp	0.77 ^a ±0.01	1.98 ^a ±0.01	2.12 ^a ±0.01	73.00 ^a ±2.83	3.32 ^a ±0.03	44.05 ^a ±0.04
75Wf10Tn15Sp	0.78 ^a ±0.00	2.17 ^a ±0.01	2.27 ^a ±0.01	72.00 ^a ±1.41	2.23 ^a ±0.03	46.82 ^a ±0.03
70Wf10Tn20Sp	0.79 ^a ±0.01	2.28 ^a ±0.01	2.44 ^a ±0.03	74.00 ^a ±1.41	1.35 ^a ±0.01	48.64 ^a ±0.03
65Wf10Tn25Sp	0.81 ^a ±0.01	2.37 ^b ±0.02	2.67 ^b ±0.01	74.00 ^a ±4.24	2.14 ^a ±0.02	50.03 ^b ±0.03
60Wf10Tn30Sp	0.85 ^a ±0.13	2.48 ^a ±0.02	2.85 ^a ±0.04	73.50 ^a ±2.01	2.22 ^a ±0.01	52.21 ^a ±0.01

Values are mean scores ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly difference at (p<0.05) using Duncan multiple range test.

100Wf= 100% wheat flour(Control); 85Wf10Tn5Sp=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour; 80Wf10Tn10Sp=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour; 75Wf10Tn15Sp=75% wheat flour/10% Tiger nut flour/15% orange fleshed sweet potato flour, 70Wf10Tn20Sp=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour; 65Wf10Tn25Sp=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour; 60Wf10Tn30Sp=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour.

Table 2: Physical properties of cookies produced from wheat, tiger nut and orange fleshed sweet potato flour blends

Sample code	Weight(g)	Diameter(cm)	Thickness(cm)	Spread ratio	Volume(cm ³)	Density(g/cm ³)	Breaking strength(g)
100Wf	4.27 ^a ±0.01	3.55 ^a ±0.01	0.62 ^a ±0.01	5.73 ^a ±0.16	6.14 ^a ±0.09	0.70 ^a ±0.00	8.13 ^b ±0.00
85Wf10Tn5Sp	5.00 ^a ±0.22	3.50 ^{ab} ±0.03	0.60 ^a ±0.01	5.89 ^a ±0.12	5.72 ^a ±0.03	0.88 ^a ±0.04	8.13 ^b ±0.00
80Wf10Tn10Sp	5.36 ^{ad} ±0.23	3.51 ^{ab} ±0.04	0.59 ^a ±0.04	5.75 ^a ±0.19	5.69 ^a ±0.29	0.95 ^{cd} ±0.01	8.13 ^b ±0.01
75Wf10Tn15Sp	6.78 ^{ab} ±0.62	3.45 ^b ±0.06	0.62 ^a ±0.02	5.61 ^a ±0.09	5.74 ^a ±0.40	1.18 ^{ab} ±0.02	10.28 ^a ±0.00
70Wf10Tn20Sp	6.48 ^{bc} ±0.78	3.57 ^a ±0.03	0.61 ^a ±0.01	5.76 ^a ±0.04	6.11 ^a ±0.05	1.07 ^{bc} ±0.12	10.28 ^a ±0.01
65Wf10Tn25Sp	6.41 ^{bc} ±0.71	3.54 ^{ab} ±0.06	0.60 ^a ±0.00	5.90 ^a ±0.10	5.91 ^a ±0.19	1.09 ^{bc} ±0.15	10.28 ^a ±0.00
60Wf10Tn30Sp	7.82 ^a ±0.35	3.53 ^{ab} ±0.01	0.61 ^a ±0.01	5.78 ^a ±0.14	5.95 ^a ±0.11	1.32 ^a ±0.02	10.28 ^a ±0.00

Values are mean scores ± standard deviation of duplicate determinations. Values in the same column with different superscripts are significantly difference at (p<0.05) using Duncan multiple range test.

100Wf= 100% wheat flour(Control); 85Wf10Tn5Sp=85% wheat flour/10% tiger nut flour/5% orange fleshed sweet potato flour; 80Wf10Tn10Sp=80% wheat flour/10% Tiger nut flour/10% orange fleshed sweet potato flour; 75Wf10Tn15Sp=75% wheat flour/10%

Tiger nut flour/15% orange fleshed sweet potato flour, 70Wf10Tn20Sp=70% wheat flour/10% Tiger nut flour/20% orange fleshed sweet potato flour; 65Wf10Tn25Sp=65% wheat flour/10% Tiger nut flour/25% orange fleshed sweet potato flour; 60Wf10Tn30Sp=60% wheat flour/10% Tiger nut flour/30%orange fleshed sweet potato flour.

**CONSUMER ACCEPTABILITY AND PROXIMATE COMPOSITION OF
KUNU-DAWA (NON-ALCOHOLIC BEVERAGE) FORTIFIED WITH *Justicia*
*secunda***

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ABSTRACT

This research evaluated the consumer acceptability and proximate composition of *Kunu-dawa* fortified with *Justicia secunda*. The process variables (Sorghum and *J. secunda* leaf) were combined using Central Composite Design from Design Expert 12 software with a total of 13 runs. Sensory evaluation results revealed that an increase in the quantity of *J. secunda* leaf affected the sensory properties of the drinks, as the results obtained for the various sensory parameters differed significantly ($p < 0.05$) from the control sample. The values ranged between 5.55-7.25 for colour, 4.80-7.15 for taste, 5.25-7.00 for viscosity, 4.65-8.15 for aroma, 4.95-7.60 for mouthfeel and 5.25-7.95 for overall acceptability. Sample OPQ (350:200 sorghum/*Justicia secunda*) was closest in preference to the control (CTR) and hence considered the best sample with *Justicia secunda*. The proximate composition of the best preferred six samples from sensory evaluation were determined which showed ash content range from (2.2-2.7%), moisture content (48.0-50.7%), crude fibre (2.7-3.7%), crude fat (2.3-3.0%), crude protein (8.0-12%), carbohydrate (31.1-32.9%). The Consumer acceptability of the *Kunu-dawa* fortified with *Justicia secunda* indicated the possibility of using *Justicia secunda* thereby expanding its use.

Keywords: Sorghum; *Justicia secunda*; *Kunu-dawa*; Consumer acceptability; Proximate.

INTRODUCTION

The traditional home of *Kunu*, a sweetened cereal-based non-alcoholic beverage, is Northern Nigeria. Depending on the season, cereal grains might be used to make the beverage (Ogoet *al.*, 2021). It is made from grains like sorghum (*dawa*), millet (*gero*), and maize (*zaki*). The type of grain used to make the beverage is mostly determined by the relative presence of any one of these in any location. *Kunu* prepared from sorghum has a milky-light brown colour, whereas that made from millet and maize has a light ash colour, according to Noah and Yusuf (2020). It is primarily drunk in the Northern regions of Nigeria however, because of its refreshing aroma and nutritious benefits, it is now generally accepted throughout practically all of Nigeria (Ekanemet *al.*, 2018). It is affordable because it is made from easily accessible local resources. As a result, the beverage is used as an alternative to carbonated beverages at social events and religious celebrations. Alcoholics also use it as a treatment.

The beverage is primarily made from cereals, and the processes used in its production could result in the loss of nutrients (Ogoet *al.*, 2021). *Kunu* may be lacking in nutritional quality, particularly in vitamins, phytochemicals, and minerals, so it may be necessary to supplement with more nutrient-dense sources (Noah and Yusuf, 2020). Utilizing and incorporating readily available medicinal plants that are high in bioactive substances including phytochemicals, vitamins,

and minerals could be a smart strategy. One of these potential therapeutic plants is *Justicia secunda*, also known as "OgwuObara" (blood tonic) in Igbo.

Tropical herbaceous plant *Justicia secunda* is a member of the *Acanthaceae* family (Nnadozie *et al.*, 2019). In Nigeria, the plants are often referred to as "blood roots," and a decoction of its leaves is used to cure injuries, anaemia, and abdominal pain (Onojaet *et al.*, 2017). Local communities typically provide *J. secunda's* aqueous extract to anaemic patients as a tea beverage. Additionally, *J. secunda's* anti-sickling, haematinic, antibacterial, and anti-hypertensive properties have been documented. However, the food value and the potential of this plant in food formulation is limited; thus, the need for this study.

MATERIALS AND METHODS

Source of Materials

Sorghum (*dawa*) grains and other ingredients including spice (ginger), sweet potatoes and packaging materials were purchased from Eke Awka Market, Awka, Anambra State, Nigeria, while fresh leaves of *Justicia secunda* were collected from a local farm in Ifite Awka and authenticated at Botany Department, Nnamdi Azikiwe University, Awka, Nigeria. All chemicals used in this study were of analytical grade.

Experimental Design

The experiment was designed using Design Expert software 12, Stat-Ease Inc. Minneapolis, Minnesota, U.S.A. Central Composite Design (CCD) was used to determine the interaction of the process variables as shown on Table 1. The experimental space had 8 non-center points and 5 center points, making a total of 13 runs.

Table 1: Design of Experiment for Fortified *Kunu-dawa*

	Factor 1	Factor 2
Run	A: Quantity of Sorghum (<i>dawa</i>)	B: Quantity of <i>Justicia secunda</i>
	ml	ml
CTR	350	0
C++	200	50
ARM	200	200
XAB	350	125
CAC	500	50
OAR	350	125
KBB	350	125
T*O	350	125
OPQ	350	200
QAR	500	200
ZOY	500	125
OO#	350	50
TBA	200	125

Production of *Kunu-dawa/Justicia secunda*

The method described in the study of Olaoye *et al.* (2016) was used to produce the *kunu-dawa/Justicia secunda* with slight modification. Cleaned sorghum grains were sorted, washed and steeped in potable water for 24 h to soften the seed. The grains were washed to remove stones, wet milled and stored in a clean bucket. The ginger and fresh sweet potatoes were separately washed and wet milled. Each measured sample of sorghum slurry (from the design) was mixed with 1.2 mL of ginger. Two-third of the slurry was mixed with boiling water (100°C) upon stirring to form gel; this was allowed to cool to 65°C and the remaining one-third of the slurry with 62 mL of sweet potatoes and *Justicia secunda* extract (from design) were added to the gel, mixed and left open to ferment overnight for 8h. It was sieved with a muslin cloth and the filtrate was sweetened with sucrose (250 g but optional), packaged in a clean plastic container and kept in a refrigerator until needed for further analysis.

Sensory Evaluation *kunu-zaki* produced with *Justicia secunda*

The *kunu-dawa/Justicia secunda* samples were subjected to sensory evaluation for the attributes of colour, aroma, mouthfeel, thickness, taste, and overall acceptability. A semi-trained twenty-member panel selected from students of Food Science and Technology Department, Nnamdi Azikiwe University, Awka were used and scores were allocated to the attributes based on a 9-point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) as described by Iwe (2002).

Proximate Composition of *kunu-dawa* produced with *Justicia secunda*

The proximate composition (moisture, fat, protein, fibre, ash and carbohydrate) of the best preferred six *kunu-dawa*/*Justicia secunda* samples were determined as described by the AOAC (2010) methods. Carbohydrate content was determined by difference.

RESULTS AND DISCUSSION

Sensory Evaluation of *Kunu-dawa* produced with *Justicia secunda*

The sensory evaluation of *Kunu-dawa* produced with *Justicia secunda* is shown on Table 2. From the results obtained, the colour of the samples were significantly different ($p < 0.05$) and ranged from 5.55-7.25. Sample TBA (200:125 g sorghum/*Justicia secunda*) had the lowest value for colour (5.55) while sample CTR (350:0 g sorghum/*Justicia secunda*) had the highest value for colour (7.25). A reduction in the quantity of sorghum grain resulted in a darker final product which could have been the reason for the lower value scored by Sample TBA.

Also, the taste of the samples was significantly different ($p < 0.05$) and ranged from 4.80-7.15. Samples T*0 (350:125 g sorghum/*Justicia secunda*) and ZOY (500:125 g sorghum/*Justicia secunda*) had the lowest values of 4.80 for taste while sample CTR (350:0 g sorghum/*Justicia secunda*) had the highest value of 7.15 for taste. The values obtained decreased with an increase in the quantity of *J. secunda*. This could be attributed to the bitter taste of the *J. secunda*, which could have affected the taste of the products.

Also, the viscosity of the sample ranged from 5.25-7.00. Samples C++ (200:50 sorghum/*Justicia secunda*) and TBA (200:125 g sorghum/*Justicia secunda*) had the lowest value of 5.25 for viscosity while samples CTR (350:0 g sorghum/*Justicia secunda*) had the highest value of 7.00. The aroma of the samples also differed significantly ($p < 0.05$) and ranged from 4.65-8.15. Samples T*0 (350:125 g sorghum/*Justicia secunda*) and ARM (200:200 g sorghum/*Justicia secunda*) had the lowest value of 4.65 for aroma, while sample CTR (350:0 g sorghum/*Justicia secunda*) had the highest value of 8.15. This could be due to the fact that the panelists were already used to the aroma of *kunu* produced from only sorghum grains.

In addition, the results obtained for mouthfeel of the samples also differed significantly ($p < 0.05$) and ranged from 4.95-7.60. Sample ARM (200:200 g sorghum/*Justicia secunda*) had the lowest value of 4.95 for mouthfeel, while sample CTR (350:0 g sorghum/*Justicia secunda*) had the highest value of 7.60. Finally, the values for overall acceptability ranged from 5.25-7.95. Sample ARM (200:200 g sorghum/*Justicia secunda*) had the lowest value of 5.25, while sample CTR (control) (350:0 g sorghum/*Justicia secunda*) had the highest value of 7.95. Sample OPQ was closest in preference to the control (CTR) and hence considered the best of the five samples selected for proximate analysis.

Table 2: Sensory scores of *Kunu-dawa* produced with *Justicia secunda*

Sample	S + J (g)	Colour	Taste	Viscosity	Aroma	Mouthfeel	Overall Acceptability
CTR	350:0	7.25 ^a ± 1.16	7.15 ^a ± 1.66	7.00 ^a ± 1.12	8.15 ^a ± 1.92	7.60 ^a ± 1.90	7.95 ^a ± 1.60
C++	200:50	6.15 ^b ± 1.56	4.90 ^b ± 1.58	5.25 ^b ± 1.74	5.20 ^b ± 1.28	5.65 ^b ± 1.66	5.90 ^b ± 1.58
ARM	200:200	5.60 ^c ± 1.42	5.10 ^b ± 1.83	5.70 ^b ± 1.83	4.65 ^b ± 1.72	4.95 ^b ± 1.57	5.25 ^b ± 1.55
XAB	350:125	6.00 ^b ± 1.68	5.00 ^c ± 2.05	5.50 ^b ± 1.96	4.80 ^b ± 1.93	5.15 ^b ± 2.27	5.45 ^b ± 1.63
CAC	500:50	5.75 ^c ± 1.33	6.10 ^b ± 1.74	6.15 ^c ± 1.46	5.80 ^b ± 1.32	5.85 ^c ± 1.81	6.35 ^c ± 1.75
OAR	350:125	5.85 ^b ± 1.69	5.45 ^d ± 2.01	5.50 ^b ± 1.31	5.00 ^c ± 1.77	5.70 ^d ± 1.92	5.75 ^c ± 1.86
KBB	350:125	6.15 ^b ± 1.63	5.70 ^c ± 1.45	5.60 ^c ± 1.60	5.90 ^b ± 1.91	5.45 ^b ± 1.84	6.05 ^c ± 1.70
T*O	350:125	5.75 ^c ± 2.33	4.80 ^d ± 2.39	6.55 ^b ± 2.56	4.65 ^b ± 2.20	5.30 ^c ± 2.51	5.70 ^b ± 2.38
OPQ	350:200	5.90 ^b ± 2.38	6.05 ^b ± 2.32	6.70 ^b ± 2.25	5.75 ^c ± 2.09	6.15 ^b ± 2.13	6.70 ^b ± 1.94
QAR	500:200	6.05 ^b ± 1.82	4.95 ^d ± 1.19	6.05 ^b ± 1.84	5.05 ^c ± 1.60	5.50 ^c ± 1.35	5.95 ^c ± 1.46
ZOY	500:125	6.15 ^b ± 1.72	4.80 ^d ± 1.73	6.70 ^b ± 2.47	5.15 ^c ± 2.03	5.60 ^c ± 2.18	5.95 ^c ± 2.08
OO#	350:50	6.30 ^b ± 2.22	5.55 ^c ± 2.35	5.70 ^d ± 2.20	5.65 ^c ± 1.92	5.65 ^d ± 2.20	6.55 ^c ± 2.01
TBA	200:125	5.55 ^d ± 2.45	5.25 ^d ± 2.22	5.25 ^c ± 1.48	5.20 ^c ± 2.26	5.80 ^c ± 1.73	6.00 ^c ± 2.20

Values are means ± standard deviation of three (3) replicates. Data in the same column bearing different superscript differed significantly ($p < 0.05$). S = Sorghum, J = *Justicia secunda*.

Proximate Composition of *Kunu-dawa* produced with *Justicia secunda*

The proximate composition (%) of *Kunu-dawa* produced with *Justicia secunda* (Table not shown) showed significant differences ($p < 0.05$) in all the parameters measured. The ash content ranged from (2.0-2.7%), moisture content (48.0-50.7%), crude fibre (2.7-3.7%), crude fat (2.3-3.3%), crude protein (8.0-12%), carbohydrate (31.1-32.9%). Ash contents increased with addition of *Justicia secunda* with sample KBB 350:125g sorghum/*Justicia secunda*) having the highest value of 2.7%. Ash content of any given food material is a measure of food quality and identity, it represents the foodstuff that is carbon free as a result of burning away of organic portion. It has proved helpful in establishing and maintaining acid-alkaline balance of the blood system (Ilodibia *et al.*, 2015). The moisture content was relatively high in all the samples tested. Ilodibia *et al.* (2015) have reported that high moisture increases spoilage and enzymatic deterioration in food products. This shows that the drink will not stay long except under refrigeration temperature or with preservative. Crude fat content was significantly low in all the samples and significantly different ($p < 0.05$) from each other. Crude fibre content was significantly different ($p < 0.05$) with

sample OPQ (350:200 g sorghum/*Justicia secunda*) having the highest value of 3.7%. Fibre aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up or azotemia. Protein content was moderate in all samples with sample OPQ (350:200 g sorghum/*Justicia secunda*) having the highest value of 12.0%. Proteins are used for building and repairing of body tissue, regulation of body processes and formation of enzymes and hormone. The carbohydrate content ranged from 31.1-32.9% with sample KBB (350:125 g sorghum/*Justicia secunda*) having the highest value of 32.9%. The result of this study slightly differs from the work of Bolarinwa(2015), who reported that *kunu-zaki* contains low protein (1.13%), fat (0.71%), ash (0.70%) and carbohydrate (28.63%) but high in moisture content (76.77%) when fortified with cowpea. Carbohydrate functions as a source of energy.

CONCLUSION

The fortification of sorghum *kunu drink* with the leaves of *Justicia secunda* was possible. Sample OPQ (350:200 sorghum/*Justicia secunda*) *kunu drink* was closest in preference to the control (CTR) and hence considered the best of the five samples. In proximate composition (%) sample OPQ (350:200 sorghum/*Justicia secunda*) contained 2.2 ash, 48.0 moisture, 2.3 crude fibre, 12.0 protein and 31.8 carbohydrate contents. The high consumer acceptability of the control sample (sorghum *kunu drink* without *J. secunda*) may be as a result of the familiarity of the panel members to the normal drink thus, influencing the overall acceptability of the drinks. Awareness on the sorghum/*Justicia secunda* *kunu drink* needs to be created because of the nutrient dense content of the drink.

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**NUTRITIONALEVALAUTION OF BISCUITS SAMPLES PRODUCED FROM
SELECTED CEREALS AND GROUNDNUT (*Arachis hypogea*).**

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ABSTRACT

Malnutrition is one of the major global concerns today. In Nigeria biscuit is one of the most common cereal based snack apart from bread, because they are readily available in local shops as ready-to-eat convenient and inexpensive food product containing digestive and dietary principle of vital importance. The objective of this paper is to improve the nutritional value with high fat and protein source such as groundnut. Biscuit samples were produced from a composite mixture of cereals (such as; sorghum, millets, maize and wheat) and groundnuts in ratio of (70: 30% each cereal to groundnut flour); enriched with egg, milk, sugar, baking powder into dough before baking in an oven. The enriched biscuits were evaluated for proximate composition where moisture content had a mean value of 4.50 ± 0.30 to 5.60 ± 0.20 %, fat content 9.50 ± 0.00 to 12.25 ± 0.50 %. The ash content of the enriched biscuit sample ranged from 1.50 ± 0.10 to 2.20 ± 0.00 %, while, the fibre content ranged within 1.25 ± 0.25 to 2.25 ± 0.75 %, and the protein content ranged from 10.35 ± 0.59 to 28.05 ± 0.25 % respectively. There was a significant difference among the samples in terms of carbohydrates content while the energy (Kcal/g) was significant in all the parameters. The minerals analyzed were calcium (3.16 – 4.49 mg/g), magnesium (2.70 – 3.86 mg/g), sodium (3.6 - 5.60 mg/g) and potassium (6.52 – 8.44 mg/g). The protein level increased due to the presence of legume. However this paper showed that biscuit samples produced from whole cereals grains incorporated which groundnut flour provide rich source of protein and minerals required by the body per daily allowance.

Keywords: Cereal grains, Groundnut, Quality assessments, Enriched biscuits.

INTRODUCTION

Biscuit is commonly regarded as a form of confectionery dried to a very low moisture content which is defined as a small crisp cake shaped made from unleavened dough. The production of biscuits is a mixture of flour and water which also contain fat, sugar and other ingredients mixed together into dough which is rested for a period and then passed between rollers to make a sheet (1). Biscuits are ready to eat, cheap and convenient diets that is consumed among all age globally (2). In sub-Saharan region of Africa most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products such as biscuits and bread.

In Nigeria, ready-to-eat baked product (snacks) consumption is continually growing and there has been increasing reliance on imported wheat. Staple crops that are grown other than wheat such as sorghum, millet, and maize can be used for baked foods (3). Therefore, the aim of this paper is to produce a balanced, nutritious, and enrich whole and refined biscuits from a composite flour and evaluates its nutritional quality.

MATERIALS AND METHODS

Sample Collection

The maize, millet, sorghum, wheat and groundnut samples were purchased from Dawana's general grain market in Kano State, Nigeria. The samples were transported to the Food Processing Laboratory of Kano University of Science and Technology for processing into flour.

Sample Preparation

Preparation of Cereal Grain Flour

The dried wholegrain samples of wheat, millet, maize and sorghum were sorted, cleaned and winnowed to remove all foreign matters followed by dry-milling separately into fine flour (4). The flour were sieved using 120 μ m sieve, packaged for further processing. The refined flours were prepared from the whole grain by sorting, cleaning, soaking followed by dehulling to remove the bran, winnowed then allowed to dry at 72°C for 12 hours. The dehulled grains were milled and sieved using (0.5mm mesh size) into fine flour (5).

Groundnuts seeds were roughly milled to prevent high release of oil content, the samples were re-dried further followed by weighing and packaged for use.

Preparation of enriched biscuit

The whole grains flour and the groundnut flour were weighed out in ratio of (70: 30%) for each cereals to groundnut and mixed in a homogenizer to obtain a uniform mixture followed by addition of ingredients such as egg (120g), milk (60g), sugar (200g), baking powder (2g) (6). The mixture was kneaded then rolled into unique shape and thickness followed by cutting into the required pan then baked at temperature 180°C for 20 minutes.

METHODS OF ANALYSIS

Proximate composition of enriched biscuits

The proximate composition of the enriched biscuit samples were determined as the major components of food sample, which include; Moisture, Lipids(fats), Ash, Protein, Fibre, Carbohydrate and energy (Kcal/g) following a standard method of analysis reported by (7) were adopted and the result expressed in percentage.

Determination of Mineral content of the enriched biscuits

The mineral content which includes; calcium, potassium, magnesium and sodium expressed in (mg/g) of biscuits samples were determined followed a method described by (8).

Data Analysis

All the parameters determined were in duplicate measurement. The data generated were statistically analyzed for mean and standard deviation using Analysis of variance (ANOVA) as described in (Onwuka, 2018). Results obtained were statistically analyzed using (Minitab 17) statistical software for mean separation and compared for significant difference at ($p \leq 0.05$) as described by (7) using LSD.

RESULTS AND DISCUSSION

Proximate Analysis of Enriched Biscuit

Table 1.0 below shows the result of proximate analysis of enriched biscuit. The moisture content of the biscuit ranged from 4.50-5.60 %, with the biscuit produced from refined grain having higher moisture content than that of whole grain. The fat content of biscuit was analyzed using (7). The fats content of the sample ranges from 9.50-13.75 %. The ash content of biscuit ranges between 1.50-2.20 %. The samples with high ash content are those produced with whole grain. The fiber content of biscuit ranges between 1.25 - 2.25%. The samples with higher fiber content are those produced with whole grain, while those with low fiber content are produced with refined grain. The protein content of the biscuit ranges between 8.21 - 38.05%, with the biscuit made from whole grain rich in protein than that of refined grain (9). Peanuts are a good source of plant-based protein. The carbohydrate content present in the biscuit is arranged in ascending order as follows 41.50%, 49.44%, 50.86%, 57.74%, 66.92%, 69.11%, 70.50%, 71.94% samples composition respectively.

Mineral analysis for enriched biscuit

The result of mineral analysis for enriched biscuit is shown in table 2.0. The calcium content in the biscuit ranged between 3.16 – 4.49 mg/g. Calcium is a major component of our bone. The magnesium content ranged between 2.25 – 3.86 mg/g. The sodium content ranged between 3.61 – 5.60mg/g. The potassium level was very high in the biscuit and this is due to the

application of fertilizer during farming. The sample with highest potassium value is sample WWG (8.41 mg/kg) while the one with low potassium content is sample RSG (5.89 mg/g).

The moisture content of biscuit samples was low which might be due to the baking process and the season which attributes to a better storage. The samples with refined grain flour had the highest moisture content due to traditional dehulling method used as a result of addition of water during dehulling process. The result of the moisture content were similar to the observation of (6) on gluten free biscuit where the moisture content ranged between (10.15-10.85%).

The biscuit sample from whole grain had a high fats content over the refined grain because of the germ, aleurone layer, endosperm, and bran had some percentage of lipids present. The sample with highest fat content were sample WMG (13.75%) while the sample with lowest fat content were sample RSG (9.50%).

The dietary fibre content of the biscuit were generally low. High ash content in food depicts those materials that are indigestible in human body. Dietary fibre cannot be digested by the body system if high but in this case, the fiber content is generally low. The higher the fiber content, the lower the water retained in biscuit which shows that the biscuit can stay for a long period of time without deteriorating(6).

Proteins are also called amino acid. Human body digest protein in food into constituent amino acid and reform them into the protein that it needs for structure as well as enzymes that carry out biochemical process in your body. Peanuts lacks significant amount of essential amino acid L-methionine. To get all of amino acid you need you have to incorporate various plant-based protein sources especially while grain in your diet. Methionine is found in cereals like wheat and corn. The result of the analysis is higher than that of (Atobatele and Afolabi 2016) on biscuit made from soybean flour and maize flour. The carbohydrate content of the biscuit increases in refined grain due to the reduction of the protein content during processing (Srivastava). The sample with low carbohydrate content is sample WWG (41.50%) while the sample with high carbohydrate content is RMG (71.94%) . the value is similar to that of (5) with (71.17%) in biscuit from maize flour and soybean flour (10).

Conclusion

The nutrient content of the enriched biscuits samples were evaluated; in which sample WWG (whole wheat composite flour) had the highest amount of protein and sample RMG (refined maize composite flour) and WMG (whole maize composite flour) had the high amount of carbohydrate content. The biscuit samples produced could be used as a snack supplement to combat protein energy malnutrition in children and provide nutrient in adult of all age. Those residing in IDP camps would benefit from a rich nutrient after consuming the biscuit samples produced especially from whole grains composites flour targeting the individually displaced persons who fed on one square meal per day as an additional supplements.

Table 1.0: Proximate Analyses of Enriched Biscuits

Samples	Moisture (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)	CHO (%)	Energy (kcal/g)
WWG	4.50 ± 0.30 ^c	11.50 ± 0.50 ^b	2.20 ± 0.00 ^a	2.25 ± 0.25 ^a	28.05±0.24 ^a	51.50 ± 1.71 ^f	364.20
WTG	4.50 ± 0.10 ^c	12.25 ± 0.50 ^a	2.10 ± 0.10 ^a	2.00 ± 0.00 ^a	20.71±0.37 ^c	58.44 ± 1.07 ^e	364.84
WSG	4.50 ± 0.30 ^c	13.25 ± 0.50 ^a	2.00 ± 0.20 ^a	2.05 ± 0.05 ^a	17.46±0.42 ^d	60.74 ± 0.47 ^d	365.80
WMG	4.90 ± 0.10 ^b	13.75 ± 0.50 ^a	1.90 ± 0.10 ^b	2.25 ± 0.25 ^a	10.28±0.66 ^e	66.92 ± 1.61 ^c	363.80
RWG	5.10 ± 0.10 ^a	9.50 ± 0.00 ^c	1.70 ± 0.10 ^b	1.75 ± 0.25 ^b	22.09±0.65 ^b	59.86 ± 1.10 ^e	365.80
RTG	5.40 ± 0.20 ^a	10.75 ± 0.25 ^c	1.50 ± 0.10 ^c	1.25 ± 0.25 ^b	11.99±0.05 ^e	69.11 ± 0.85 ^b	367.40
RSG	5.20 ± 0.20 ^a	10.75 ± 0.25 ^c	1.70 ± 0.10 ^b	1.50 ± 0.15 ^b	10.35±0.59 ^e	70.38 ± 1.02 ^a	365.92
RMG	5.60 ± 0.20 ^a	11.00 ± 0.50 ^b	1.50 ± 0.10 ^c	1.75 ± 0.25 ^b	8.21 ± 0.55 ^f	71.94 ± 1.60 ^a	364.60

NOTE: values are presented as mean of two replication ± SD; the samples with the same subscripts are not significantly different at ($P \leq 0.5$) level of significance.

Key:

WWG:70%Whole Wheat Flour and 30% Groundnut Flour, WSG=70% Whole Sorghum Flour and 30% Groundnut Flour, WTG=70% Whole Millet Flour and 30% Groundnut Flour, WMG=70% Whole Maize Flour And 30% Groundnut Flour, RWG= 70% Refine Wheat Flour and 30% Groundnut Flour, RSG=70% Refine Sorghum Flour and 30% Groundnut Flour, RTG= 70% Refine Millet Flour and 30% Groundnut Flour, RMG= 70% Refine Maize Flour and 30% Groundnut Flour.

Table 2.0: Mineral Content of Enriched Biscuits.

SAMPLES	Ca (mg/g)	Mg (mg/g)	Na (mg/g)	K (mg/g)
WWG	4.32 ± 0.07 ^a	3.07 ± 0.01 ^b	4.98 ± 0.01 ^b	8.44 ± 0.06 ^a
WSG	3.99 ± 0.03 ^a	3.28 ± 0.04 ^a	5.00 ± 0.02 ^a	7.68 ± 0.01 ^b
WTG	4.49 ± 0.06 ^a	3.84 ± 0.06 ^a	5.60 ± 0.03 ^a	8.21 ± 0.02 ^a
WMG	4.06 ± 0.05 ^a	3.86 ± 0.02 ^a	5.12 ± 0.02 ^a	8.01 ± 0.09 ^a
RWG	3.81 ± 0.07 ^b	2.15 ± 0.02 ^c	3.61 ± 0.01 ^c	6.82 ± 0.03 ^b
RSG	3.24 ± 0.01 ^c	2.20 ± 0.02 ^c	3.99 ± 0.05 ^c	5.89 ± 0.07 ^c
RTG	3.57 ± 0.01 ^b	2.53 ± 0.03 ^b	4.22 ± 0.01 ^b	6.77 ± 0.02 ^b
RMG	3.16 ± 0.02 ^c	2.70 ± 0.05 ^b	4.03 ± 0.01 ^b	6.52 ± 0.05 ^b

NOTE: values are presented as mean of two replication ± SD; the samples on same column with the same subscripts are not significantly different at ($P \leq 0.5$) level of significance.

Key:

WWG:70%Whole Wheat Flour and 30% Groundnut Flour, WSG=70% Whole Sorghum Flour and 30% Groundnut Flour, WTG=70% Whole Millet Flour and 30% Groundnut Flour, WMG=70% Whole Maize Flour And 30% Groundnut Flour, RWG= 70% Refine Wheat Flour and 30% Groundnut Flour, RSG=70% Refine Sorghum Flour and 30% Groundnut Flour, RTG= 70% Refine Millet Flour and 30% Groundnut Flour, RMG= 70% Refine Maize Flour and 30% Groundnut Flour.

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QUALITY EVALUATION OF MASA FROM BLENDS OF MAIZE AND TOMATO SEED FLOURS

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ABSTRACT

The proximate composition and acceptability of masa from blends of maize and tomato seed flour was investigated. Masa formulations containing maize blended with tomato seed were prepared in the ratio 100:0 - A, 95:5 - B, 90:10 -C, 85:15 - D, 80:20 -E. Proximate composition of the samples revealed moisture 2.04-3.96 %, ash 0.45-1.90 %, crude fat 4.70-14.71 %, crude protein 9.81-13.14 %, crude fiber 0.3-1.26 %, carbohydrate 65.04-79.58 %. Increase in substitution with tomato seed increased the ash, crude fat, crude protein, crude fiber, and decreased moisture and carbohydrate content. Generally, sample B (95:5 %)maize-tomato seed blends was the most acceptable while sample E (80:20 %) maize-tomato seed flour blends was the least acceptable. The study indicates that an acceptable protein enriched maize masa could be produced at 5% level of tomato seed flour.

Key words: Masa, Maize, Tomato seed, proximate composition and acceptability

Introduction

Masa (waina) is a cereal-based spontaneously fermented puff batter or cake cooked in a pan with individual cuplike depression popularly consumed as an adjunct to breakfast porridges. *Masa* is a cereal based food product which is deficient in protein both in quality and quantity (Nkamma, 1998). It is produced from maize (*Zea mays*), millet (*Pennisetum typhoides*), sorghum (*sorghum vulgare*) or rice (*Oryza sativa*) depending on the producer's preference. The addition of tomato seed flour in maize for masa production could help in improving the nutrient content of the masa. Tomato have been reported to contain approximately 24.50% crude protein and are high in glutamic acid and aspartic acid(Persia *et al*; 2003) *Masa* is a very popular staple food consumed by over 80 % of the Northern Nigeria population of about 47 million (Ayo *et al.*, 2014). Though *masa* is popular as Nigeria, it receives very little research attraction (Sogi, 2001).The use of maize-tomato seed flour combination in the production of an acceptable *masa*, would not only help to reduce tomato seed waste but could also improve the nutritional value of the *Masa*. The objective of this research was to produce and asses the quality of masa produced from blends of maize-tomato seed flour.

MATERIALS AND METHODS

White variety of Maize (*Zea mays* L.), active baker's yeast (*Saccaromyces cerevisiae*), salt, sugar, tomato seeds, *Kanwa* or *trona* (Sodium bicarbonate) used for the work were purchased from Ega Market Idah, Kogi State.

Preparation of maize flour

Maize grains were cleaned, weighed, washed, steeped in water for 12 h at room temperature, The grains were wet milled and then was decanted, dried, grounded and sieved

Preparation of tomato seed flour

Tomato seed were separated from the pomace, by sedimentation technique AOAC (2005) and dehydrated at 70 °C for 5 hr in a cabinet dryer AOAC, (2005). Seed were ground using hammer mill and ground again to pass through 25 µm sieve to obtain fine powder: Maize-tomato seed flour were formulated in different ratios 100:0, 95:5, 90:10, 85:15, 80:20 .

Preparation of *masa*

Masa was produced using the slight modified method of AOAC, (2005). Proportions of maize and tomato seeds flour were mixed with yeast, sugar and water. The batter obtained was covered to ferment for 12 h, neutralized with trona, and fried in a hot oil pan in 5 min.

Proximate and sensory analysis

The proximate composition for moisture, ash, fat, protein, crude fiber was determined according to standard analytical methods and carbohydrates was calculated by difference. The *masa* were subjected to sensory evaluation by 20 untrained panelists (students and staff) from the polytechnic community.

Results and discussion

The proximate showed moisture 2.04-3.96 %, ash 0.45-1.90 %, crude fat 4.70-14.71 %, crude protein 9.81-13.14 %, crude fiber 0.3-1.26 %, carbohydrate 65.04-79.58 %. Increase in substitution with tomato seed increased the ash, crude fat, crude protein, crude fiber, energy value, and decreased moisture and carbohydrate content. The moisture content of all samples was within the acceptable limit of not more than 10 % for long term storage of flour. Moisture content of a food is influenced by type of food, food variety, and the storage conditions (Opponget *et al.*, 2015). The Ash content of the samples ranged from (0.45-1.90 %). Sample E (80:20 %) had the highest ash content at (1.90 %) while sample A (100 %) maize flour with (0.45 %) ash content was the least. The result of the ash content compared favorably to the values of (0.65-1.30 %) reported by Silvia *et al.*, (2019). The percent protein content of the flour samples ranged from 13.14-9.81 %. The protein content of sample E (85:20 %) had the highest at (13.14 %), sample A (100 %) maize flour had the least at (9.81 %). The result compared favorably with those reported by Silvia *et al.*, (2019).

The average mean score for aroma ranged from 7.89-5.55 with sample E (80:20 %) and sample A (100 %) maize flour rated lowest and highest respectively. This could be associated to the fermentation of batter for 8hours, during the production of *masa*. There was significant ($P < 0.05$) difference in the *masa* samples. However, sample A was insignificantly different from sample B as well as sample C, D and E. The aroma of the *masa* sample decreased with increase in the level of tomato seed flour.

The average mean score for taste of the five samples ranged from 5.30-7.65 with sample D (85:15 %) and sample B (95:5 %) rating the lowest and highest respectively. There was

significant ($P < 0.05$) difference in the *masa* samples. Sample A and B were insignificantly ($P > 0.05$) different as well as sample C, D and E.

The overall acceptability of the five samples showed that sample B (95:5%) was the most accepted while sample E (80:20 %) was the least accepted of the five samples with mean scores of 8.10 and 5.60 respectively.

Table 1 Proximate composition (%) and Sensory properties of *masa*

Samples	Moisture	Ash	Fat	Protein	Fiber	Carbohydrate	Aroma	Taste
A	5.28±0.00 ^a	0.45±0.01 ^a	4.70±0.11 ^a	9.81±0.00 ^a	0.3±0.01 ^a	79.58± 0.09 ^a	7.80±1.24 ^b	7.60±0.99 ^b
B	3.36±0.00 ^b	1.45±0.00 ^c	6.30±0.11 ^b	10.78±0.01 ^c	0.96±0.00 ^c	77.16± 0.12 ^d	7.55±1.09 ^b	7.65±1.09 ^b
C	5.35±0.00 ^a	1.65±0.00 ^d	7.35±0.02 ^c	9.90± 0.00 ^b	1.09±0.00 ^d	74.68± 0.03 ^c	5.90±1.65 ^a	5.55±1.99 ^a
D	2.04±0.14 ^a	1.20±0.00 ^b	10.89±0.00 ^d	11.56±0.00 ^d	0.80±0.01 ^b	73.48± 0.01 ^b	5.80±1.70 ^a	5.30±1.96 ^a
E	3.96±0.00 ^c	1.90±0.00 ^e	14.71±0.00 ^e	13.14±0.01 ^e	1.26±0.01 ^e	65.04± 0.00 ^a	5.55±1.70 ^a	5.50±1.90 ^a

Results are mean determination ± standard deviation

Means with the same superscript on the same column are not significantly different ($P > 0.05$)

Conclusion This study indicates that partial substitution of maize flour with tomato seed flour produced protein enriched *masa* that compared favorably with maize *masa* in acceptability. It is recommended that 5 % level of tomato seed flour substitution be used for nutritionally improved and acceptable *masa*.

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PROXIMATE AND ACCEPTABILITY OF *MASA* PRODUCED FROM FLOUR BLENDS OF BROKEN RICE AND ALMOND FRUIT SEED

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ABSTRACT

Proximate and acceptability of masa produced from blends of broken rice and almond fruit seed was undertaken. Masa is a traditional cereal based food product which is generally deficient in protein quantity and quality. The objective of this research was to enrich rice masa with highly underutilized indigenous crop Almond fruit seed flour. The following blends were formulated; sample A (100:0), sample B (90:10), sample C (80 Rice: 20), sample D (70: 30), sample E (60:40). The flour blends were used in masa production. The samples were subjected to proximate and acceptability according to standard method. The protein, crude fat, crude fiber, and ash contents increased as the level of almond increased 4.91 % -2.73%, 4.69 %-11.99 %, 0.32 % -1.59 %, and 0.43 %-2.42 % respectively while carbohydrate decreased 77.64% - 45.03%. The general acceptability showed a range of 7.93 to 5.87 scores and there were significant differences observed. The research indicates that protein enriched and acceptable masa could be produced from 20% Almond in rice flour.

Key words: Masa, Almond, Proximate composition, acceptability and protein enriched

INTRODUCTION

Masa is fermented bread-like product which is round shape with brown smooth body and crippling edges made from millet, maize or rice flour (Ayo *et al.*, 2012). The product is cooked in a pan with individual *masa* cuplike depression and is consumed in various forms by all age groups in the Northern states of Nigeria but less so in the southern and eastern state. Like most single cereal-based products which are generally poor in protein and micronutrients, rice-masa is no exception as it deficient in amino acid lysine (Ayo *et al.*, 2012). The tropical Almond (*Terminallacatappa*) is one of the lesser known legumes found in the tropics and in Nigeria eco-system. Almond fruit is one of the underutilized crops and is not well known as a good source of protein. The seed was reported to contain 25.80 % protein (Ezeokonkwo, 20004). The broad objectives of the study was to evaluate the quality of *Masa* produced from blends of Rice and Almond seed in order to improve the nutrient of rice masa and improve the utilization of almond seeds.

MATERIALS AND METHODS

The rice (broken white rice) was purchased from Bata market in Kano and all other ingredients were purchased from Ega market in Idah Kogi state. The Almond fruits were gathered from various trees in the Polytechnic premises in Idah Kogi state.

Rice flour was prepared by modification of the method as described by Nkamma, (2015). The rice (White broken rice) was cleaned and washed, soaked for 10 hours to aid its fermentation, which is necessary for the production of *masa*. It was then wet milled dried.

Almond fruit was sorted to remove extraneous materials. The fruits were sun dried to facilitate deshelling. The dried fruits were deshelled by cracking along the margins with a piece of pebble to obtain the brown spindle-kernels. The kernel was dried at 60°C four hours to constant moisture level. The almond seeds were milled and sieved (0.05mm sieve) to obtain almond flour.

Rice flour was blended with Almond seed at different proportions, sample A (100:0), sample B (90:10), sample C (80 Rice: 20), sample D (70: 30), sample E (60:40). Yeast, sugar, and water was added to the blends, mixed and battered, which was further allowed to ferment for 12 hours, then the neutralization process, where salt was added and the sample mixed thoroughly. The final stage was the cook on hot pan for 5 mins.

The proximate composition for moisture, ash, fat, protein, crude fiber was determined according to standard analytical methods and carbohydrates was calculated by difference, Energy value of *masa* samples was calculated using Atwater values. Acceptability was carried out on the *Masa* sample, 25 mins after preparation by twenty (20) panelists from the Department of Food Science and Technology, Federal Polytechnic, Idah. Each sample was rated on 9 point hedonic scale

Results and Discussion

The result of the proximate composition in Table 1 indicates that there was significant difference between the *masa* supplemented with almond flour and the control in terms of protein content. Substituting rice flour with almond flour improved the protein value of the *masa*. The increase in protein of a *masa* could be attributed to the high protein content of almond flour. This result agrees with a reported by Ayo et al. (2012) that produced bread from wheat – almond fruit composite flour. The addition of almond decreases the carbohydrate content of the samples as expected. The carbohydrate content decreased following the addition of almond flour when compared to the control. Nkamma (2015) recorded that cereals such as rice, wheat is richer in carbohydrate than legume.. The result compares favorably with that recorded by Nkamma (2015) who reported decrease in carbohydrate content of whole wheat – Bambara groundnut bread. There were significant differences observed between the samples general acceptability. The study shows that an acceptable, protein and mineral enriched *masa* could be prepared from up to 20% Almond in rice flour.

Table 1: Acceptability (GA) and proximate composition of masa samples produced from the blend rice and Almond Flour

RF-AF		Proximate Composition (%)						
Sample s	GA	Moisture	Protein	Fats	Fiber	Ash	CHO	Energy value (Kcal/100g)
100-0 A	7.93 ^a	12.27 ^a ± 0.70	4.91 ^a ± 0.18	4.69 ^a ± 0.33	0.32 ^a ± 0.21	0.43 ^a ± 0.67	77.38 ^e ± 0.40	371.37 ^a ± 0.17
90-10 B	7.07 ^b	14.62 ^b ± 0.19	8.81 ^a ± 0.17	5.04 ^a ± 0.62	0.33 ^a ± 0.82	0.48 ^a ± 0.14	70.72 ^d ± 0.98	368.48 ^{da} ± 0.79
80-20 C	7.07 ^b	15.49 ^c ± 0.16	12.28 ^c ± 0.32	9.02 ^b ± 0.00	0.66 ^b ± 0.00	0.99 ^b ± 0.021	61.55 ^c ± 0.19	376.5 ^c ± 0.78
70-30 D	5.87 ^c	15.55 ^c ± 0.54	19.30 ^d ± 0.71	10.11 ^a ± 0.62	1.30 ^c ± 0.18	1.97 ^c ± 0.27	51.77 ^b ± 0.54	375.27 ^d ± 0.44
60-40 E	5.87 ^c	16.22 ^c ± 0.14	22.73 ^d ± 0.99	11.99 ^d ± 0.12	1.59 ^d 0.16	2.42 ^d ± 0.25	45.03 ^e ± 0.41	378.95 ^e ± 0.23
LSD	0.717	0.136	0.320	0.160	0.114	0.135	0.207	0.234

Means within the same columns with different superscript were significantly (P<0.05) different.

KEY

RF= Rice Flour

AF= Almond fruit flour

LSD= Least significant difference

Conclusion

From the study, it was concluded that *an acceptable and protein enriched masa could be prepared from up to 20% Almond in rice flour.*

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EFFECT OF MALTING AND FERMENTATION ON THE QUALITY OF MAIZE FLOUR FORTIFIED WITH AFRICAN YAM BEAN FOR STIFF PORRIDGE

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ABSTRACT

Effect of malting and fermentation of maize and substitution with African yam bean for stiff porridge was studied. Five samples were prepared- none malted none fermented maize alone 100 % (sample A), 55.56 % none malted none fermented maize: 44.44 % African yam bean (sample B), 58.90 fermented maize: 41.02% African yam bean (sample C), 55.93 % germinate maize: 44.07 % African yam bean (sample D), 57.52 % malted and fermented maize: 42.48%.African yam bean (sample E). Samples with African yam bean flour were prepared to obtain flour blends with 16% protein level according to Protein Advisory Group. The samples were analyzed and were used for production of stiff porridge for overall sensory evaluation. The proximate results showed that sample A (maize flour) had the least moisture (9.21%) while sample E had the highest moisture content (10.87 %). There was an increase in the ash content and crude fiber contents from 1.49% - 3.87 % and 0.89 % - 6.33 % respectively. Fat and carbohydrate content decreased from 5.21% - 2.15% and 72.40% - 61.36% respectively. The mineral content increased significantly ($p < 0.05$) with fermentation, malting, and addition of African yam bean except for phosphorus in samples A and B. The functional properties showed that water absorption capacity ranged from 1.84 mL/g - 1.25 mL/g, bulk density ranged from 0.71 g/mL - 0.76 g/mL, and swelling index ranged from 1.35 mL/g -1.81 mL/g. The sensory evaluation showed that all the samples were significantly different. Samples A, B, and C were generally accepted. This study indicates that germination and/or fermentation of maize with added African yam bean flour had positive effects on the quality of stiff porridge

Key Words: Malting, fermentation, maize, African yam bean, and stiff porridge

INTRODUCTION

Stiff porridge commonly known as turning food is regarded as an important source of calorie in Nigeria. It is a thick paste made from starch dense foodstuffs like cassava, maize, yam, plantain etc. Depending on its source it goes by many names like *amala*, *fufu* or *tuwo* in Nigeria, *ugali* in Kenya, Uganda, and Tanzania. Stiff porridge is a cereal based food, it is deficient in some essential amino acids notably lysine, and tryptophan (Gernahet *al.*, 2011). Another problem associated with maize stiff porridge is that of textural and sensory quality inadequacies which reflects in its inability to form highly elastic, long bodied gel, its ability to retrograde when cooled and its tendency to brittle easily when moulded during meal consumption (Boladeet *al.*, 2009). This causes an unsatisfactory enjoyment and has made it

unappealing to people. Studies have shown that populations in regions with heavy maize consumption may suffer malnutrition (Ekpa *et al.* 2018). Efforts at improving quality of maize have been largely geared toward supplementation with legumes or animal proteins bean (Adelekan *et al.*, 2012). The Broad objective of this research was to evaluate the influence of malting and fermentation on maize based stiff porridge supplemented with African yam.

MATERIALS AND METHODS

Maize grains and African yam bean seeds were purchased from Wurukum Market Makurdi Benue State. The seeds were carefully sorted to separate dirt, dust, stones and other contaminants, steeped in clean water for 12 hours and sundried. The dried maize was milled in a grinder (grinder (M/S Sujata: New Delhi) and sieved (0.05mm sieve) to obtain maize flour. Malting was carried out by a method described by Gernah *et al.* 2011. Fermentation of the maize grain was carried out as described by Gernah *et al.* (2011).

Sample preparation

Five samples were prepared- none malted none fermented maize alone 100% (sample A), 55.56% none malted none fermented maize: 44.44% African yam bean (sample B), 58.90 fermented maize: 41.02% African yam bean (sample C), 55.93% germinate maize: 44.07% African yam bean (sample D), 57.52% malted and fermented maize: 42.48%. African yam bean (sample E)

Proximate, functional and sensory analysis

The proximate composition for moisture, ash, fat, protein, crude fiber was determined according to standard analytical methods and carbohydrates was calculated by difference, Functional properties was analyzed as described by AOAC, (2005). The masa were subjected to sensory evaluation by 20 untrained panelists (students and staff) from the polytechnic community.

Results and Discussion

The proximate, functional properties and acceptability results are presented in Table 1. The moisture content ranged from 9.21 % - 10.87 % with sample A (control) having the least and sample E having the highest. The low values of the moisture content of the samples are a good indicator of their potential to have a long shelf life. The protein content of sample A (control) 10.81 % was significantly different from that of the other samples (sample B, C, D, and E), which ranged from 16.01% - 16.09 %. The ash content of the flour increased from 1.49% to 3.87% with sample A (control) having the least value of 1.49% while sample E had the highest value of 3.87%. The results showed decreased in water absorption capacity which could be due to the addition of African yam bean because, according to Yusufu and Ejeh (2018) low values of water absorption capacity indicates compactness of protein structure,. Research also shows that malting and fermentation led to increase in water absorption capacity as a result of increase in amount of soluble sugars, while other research work like those of (Adelekan *et al.*, 2012)), reported a decrease in water absorption capacity as a result of fortification with a legume. There was a significant difference ($p < 0.05$) in the oil absorption capacity of the sample A (control) and the other samples. The values ranged from 1.30ml/g – 1.60ml/g.

Table 1: Proximate composition (%), Functional properties and General Acceptability (GA) of Properties of flour used
in making stiff porridge

Samples	Moisture	Ash	Protein	Fiber	Fat	Carbohydrate	WAC (ml/g)	BD (g/ml)	SI(ml/g)	GA
A	9.21 ^a ±0.1	1.49 ^a ±0.1	10.81 ^b ±0.1	0.89 ^a ±0.1	5.21 ^a ±0.1	72.40 ^a ±0.0	1.84 ^a ±0.4	0.71 ^a ±0.00	1.39 ^a ±0.1	7.6a
B	10.84 ^a ±7	3.56 ^a ±0.1	16.06 ^a ±0.6	6.21 ^a ±0.1	2.31 ^a ±0.1	61.53 ^a ±0.5	1.30 ^a ±0.4	0.73 ^a ±0.01	1.35 ^a ±0.1	6.4b
C	10.21 ^a ±1	3.55 ^a ±0.1	16.01 ^a ±0.4	6.33 ^a ±0.0	2.21 ^a ±0.1	61.36 ^a ±0.1	1.40 ^a ±0.4	0.71 ^a ±0.01	1.81 ^a ±0.1	6.5b
D	10.25 ^a ±0.1	3.57 ^a ±0.1	16.04 ^a ±0.1	6.06 ^a ±0.1	2.23 ^a ±0.1	61.36 ^a ±0.1	1.25 ^a ±0.7	0.71 ^a ±0.00	1.49 ^a ±0.3	2.6c
E	10.87 ^a ±0.2	3.87 ^a ±0.01	16.09 ^a ±0.16	5.46 ^a ±0.08	2.15 ^a ±0.21	61.52 ^a ±0.5	1.30 ^a ±0.00	0.76 ^a ±0.01	1.71 ^a ±0.01	2.00c
LSD	0.07	0.03	0.20	0.25	0.82	0.75	0.25	0.01	0.29	1.00

• Values are mean± standard deviation of duplicate determination

Values with different superscript within the same column are significantly different

The bulk density ranged from 0.71 g/ml to 0.76 g/ml with sample E having the highest value of 0.76g/mL. According to Yusufu and Ejeh (2018), swelling index which is the measure of the ability of starch to imbibe water and swell ranged from 1.35 mL/g to 1.81 mL/g. The result showed that sample C had the highest swelling index of 1.81mL/g as compared to the control (sample A).at (**P<0.05**). The general acceptability of the samples shows there were significantly ($p<0.05$) different from the control sample (sample A), and sample A was rated the highest 7.67 followed by sample C 6.53 while sample E was rated lowest.

Conclusion

Malting and/or fermentation of maize grains prior to the production of flour meant for producing stiff porridge resulted in a decrease in the water and an increase in the bulk density and swelling capacity. The process and addition of African yam bean also has positive effects on the proximate composition of maize based stiff porridge, but the general acceptability of the stiff porridge was adversely affected.

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PROXIMATE COMPOSITION, MINERAL CONTENTS AND SENSORY SCORES OF NAKIYA PRODUCED FROM THE BLENDS OF FARO 44 AND GROUNDNUT.

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Abstract

Nakiya is a snack, locally produced from the blends of (100%, 95:5, 90:10, 85:15) rice flour (faro 44) and groundnut. The Raw rice was cleaned (sorted, washed, dried), milled and mixed together with the groundnut and spices (clove, ginger, pepper) pounded and moulded into the desired shaped of nakiya. The samples were subjected to proximate analysis, mineral determination and acceptability rate. The moisture content ranges from 9.92 – 9.39%, protein 7.26 – 14.27%, fat 2.60 - 4.51%, ash 0.70 – 1.64%, fiber from 1.02 - 2.03 %, carbohydrate with a value of 68.16 – 78.50% and energy with a value of 366.44-370.31%.. Rate of substitution increased with an increased protein, fat, crude fibre, and ash while carbohydrate and moisture content decreased. While the Mineral content ranged with calcium 21.51–25.03 mg/g, iron 0.30–0.35 mg/g, potassium 4.69 – 10.11 mg/g and Zinc 0.16 – 0.23 mg/g. Minerals include calcium; magnesium, zinc; iron and copper content were evaluated. It was found that the rate of substitution affects the nutritional composition of the nakiya. Essential elements such as iron, zinc and calcium were significant at $p > 0.05$. Nakiya produced from blends of rice flour (FARO44) and groundnut was significantly accepted and higher in protein contents. Sample D (85%Faro, 15%Groudnut) is higher in amount of Calcium (containing 15 % groundnut) and iron is also attributed to sample C (90%Faro, 10%Groudnut) and D (85%Faro, 15%Groudnut). Sensory evaluation showed that all the samples were accepted in terms of all the sensory attributes.

Key words: Nakiya, Faro 44, proximate composition, Mineral elements, Sensory scores
Introduction.

In Nigeria, the common traditional Hausa rice products are *Nakiya* and *Masa*. But information on *nakiya* is scanty. Therefore, *Nakiya* is described as an indigenous rice snack that is generally produced in the northern part of Nigeria. It is made by mixing rice flour, sugar, spices, and water, pounding, moulding with oil to the desired shape. Rice is a great source of carbohydrate which is classified as whole grain and contains a range of essential nutrient such as vitamin A and B, Phosphorous, Sodium, Manganese, Potassium and Magnesium (Duke, 2000). The rice grain consists of 75-80 % starch, 12 % water and only 7 % protein with a full complement of amino acids (Oko *et. al.*, 2011). Being a rich source of dietary energy, rice is a good source of thiamine, riboflavin and niacin (Oko *et. al.*, 2011). Groundnut is a legume which contains all the 20 amino acids in variable proportions and is the

biggest source of the protein called arginine (USDA 2014). According to Protein Digestibility Corrected Amino Acid Score (PDCAAS) groundnut proteins and other legume proteins such as soy proteins are nutritionally equivalent to meat and eggs for human growth and health (FAO 2002). The amino acid profile of the peanut meals shows that it can be an ingredient for protein fortification (Yu et al. 2006). Attempts had been made by other researchers, to make home process products with partial replacement of rice flour using common legume available of which groundnut is one of them mainly grown in northern Nigeria. Groundnut is the common legume grain grown by farmers in the Semi-Arid region of northern Nigeria. Incorporation of groundnut is to enhance the nutritional composition of the *Nakiya*. With that, groundnut is known to be rich in plant protein (Antony, *et.al*; 1993). The objective of this study is to produce *nakiya*, and to determine the proximate composition, mineral contents and sensory attributes of the *nakiya*.

Materials and methods

Rice (Faro 44) and groundnut were obtained from Kano State Agricultural and Rural Development Authority (KNARDA), while spices such as cloves, ginger and pepper from Rimi Market in Kano state. The rice was cleaned, sorted, washed, dried, mixed with spices and milled into flour. The rice flour and the groundnut four were mixed together pounded, moulded into a desired shape and package for analysis. Samples were subjected to the following formulations A(100% Faro), B(95% Faro, 5% Groudnut), C (90%Faro, 10% Groudnut), D (85%Faro, 15% Groudnut). The proximate composition of the *nakiya* was adopted by (AOAC, 2000) standard method of analysis (moisture, protein, crude fat, crude fibre, ash carbohydrate). Mineral element determination of selected elements or selected mineral constituents was investigated using Atomic Absorption Spectrometry method as described by (Adeniyi *et al.*, 1991). A nine 9 point hedonic scale was used to evaluate *nakiya* produced from the blends of faro 44 and groundnuts as described by Larmond, (1976). All determinations were done in duplicate and replicated thrice, and data collected were analyzed using SPSS 2016 version.

Results and Discussion

Table 1.0 below shows that proximate composition of four different samples of *Nakiya*, where the moisture content ranges from 9.92 – 9.39%, protein 7.26 – 14.27%, fat 2.60 - 4.51%, Ash 0.70 – 1.64%, Fiber from 1.02 - 2.03 %, carbohydrate with a value of 68.16 – 78.50% and energy with a value of 366.44-370.31%.. This is in agreement with the findings of Ebuehi and Oyewole (2007) who analyzed the effect of cooking and soaking on physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign rice varieties in Nigeria. Protein content of *Nakiya* tends to increase as the groundnut level increased, sample B (95% faro, 5% of groundnut), C (90% faro, 10% groundnut) and sample D (85% faro, 15% groundnut) had high protein content in contrast with sample A (100 % faro). For the protein content, high protein was found in the products, with a range of (7.26 - 14.27 %)., As the rate of substitution increased, the protein, fat, crude fibre and ash

increased, while carbohydrate and moisture decreased. As reported by (Yousaf, 1992), cereals are generally high in carbohydrate (they store starch as source of energy), where the carbohydrate level decrease with increase in the groundnut content in the samples. Sample (A 100% faro) was found to be high in carbohydrate which is attributed to 100% faro 44. Mineral content ranged with calcium 21.51–25.03 mg/g, iron 0.30–0.35 mg/g, potassium 4.69 – 10.11 mg/g and Zinc 0.16 –0.23 mg/g. This implies that sample D (85% faro,15% groundnut) resulted in high amount of Calcium in sample D (85% faro, 15 % groundnut) and iron is also attributed to sample D(85% faro,15%groundnut) and C (90% faro,10%groundnut). The result of the sensory evaluation showed that all the samples were accepted in terms of all the sensory attributes (aroma, colour, taste, texture and overall acceptability).

Conclusion

Nakiya produced from this blend of faro 44 and groundnut consists of all the required nutrients needed by the body. Possession of iron and zinc showed that nakiya of its kind is for growth and maintenance of the immune function which enhanced prevention of infectious diseases.

Table 1.0 Proximate Composition, Mineral Contents and sensory Scores of Nakiya produced from the Blends of Faro 44 and Groundnut.

Proximate Composition (%) and Calorie Values (Kcal/100g)				
Parameters	A	B	C	D
Samples				
Moisture %	9.92±0.15 ^a	9.77±0.03 ^b	9.54±0.01 ^c	9.39±0.05 ^d
Protein %	7.26±0.04 ^a	9.69±0.01 ^c	12.48±0.02 ^b	14.27±0.38 ^a
Crude fat %	2.60±0.06 ^a	3.53±0.04 ^c	4.05±0.05 ^b	4.51±0.01 ^a
Crude fibre%	1.02±0.02 ^a	1.47±0.03 ^c	1.86±0.02 ^b	2.03±0.02 ^a
Ash %	0.70±0.01 ^c	0.95±0.02 ^b	1.40±0.03 ^a	1.64±0.02 ^a
Carbohydrate %	78.50±0.19 ^a	74.59±0.07 ^b	70.67±0.01 ^c	68.16±0.27 ^d
Energy kcal	366.44	368.89	369.65	370.31
Mineral composition mg/ g				
Iron (Fe mg/ g)	0.30 ± 0.02 ^a	0.33 ± 0.02 ^c	0.34 ± 0.01 ^b	0.35 ± 0.04 ^a
Potassium (k mg/ g)	5.79 ± 1.06 ^c	9.55 ± 0.34 ^b	10.11 ± 0.13 ^a	4.69 ± 0.28 ^d
Zinc (zn mg/ g)	0.21± 0.07 ^b	0.20 ± 0.01 ^c	0.23 ± 0.01 ^a	0.16 ± 0.01 ^d
Calcium (ca mg/ g)	24.94 ± 0.20 ^b	21.51 ± 0.07 ^d	22.54 ± 0.05 ^c	25.03 ± 0.05 ^a
Sensory scores				
Aroma	5.40±1.26 ^c	5.10±0.99 ^d	5.90±1.10 ^b	6.20±1.03 ^a
Colour	5.60±1.07 ^b	5.40±1.07 ^c	5.60±1.57 ^b	6.10±1.52 ^a
Taste	5.30±1.33 ^d	5.40±1.43 ^c	6.60±1.71 ^a	6.10±1.66 ^b
Texture	5.90±1.24 ^d	6.12±1.49 ^c	6.20±1.98 ^b	6.26±1.68 ^b
General acceptability	6.05±1.16 ^d	6.10±1.33 ^c	6.23±1.39 ^b	6.32±1.22 ^a

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p> 0.05 level key: 9 point hedonic scale (9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2 moderately dislike, 1=strongly dislike. ``A = 100% Faro, B= 95% Faro, 5% Groudnut , C =90%Faro, 10% Groudnut, D=85%Faro, 15% Groudnut ``

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PROXIMATE COMPOSITION, PHYSICAL PROPERTIES AND MIXOLAB INDICES OF FIVE DIFFERENT DURUM WHEAT GRAINS AND FLOURS.

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Abstract

The proximate compositions were estimated using compositional analysis of Association of Official Analytical Chemists, while the grains length, width and thickness were determined using Buhler lens measurement equipment. Mixolab was determined using mixolab device. Analysis of variance shows that there was significant difference ($p < 0.05$) in the proximate compositions (moisture, protein, crude fat, crude fibre, ash and carbohydrate) of the wheat varieties studied Gerardo, Altar, Ranco, Plata and Guayacan. Significant difference ($p > 0.05$) exists in the physical properties of the durum wheat varieties 1000kernel weigh, bulk density, length, width and thickness of the grains. Mixolab indices of the flour (water absorption capacity 8.50 to 9.00%, mixing 2.50 to 3.00mins, gluten ranged from 7.50 to 8.00%) showed a significant different at $p > 0.05$. Gerardo, Altar, Ranco, Plata and Guayacanhad significantly higher gluten and their ranged of chemical composition were within the specific range. The mixolab indices showed that the wheat grains had good water absorption and high gluten quality, are good for the production of pasta, spaghetti and other local wheat products such as alkaki and gurasu.

Introduction;

Wheat, like most grains, thrives in cool climates and tends to do poorly in warm, humid climates, which often ruins the crop through disease. Although wheat prefers cool climates, they do not grow as far north as heavier grains, such as rye and oat (Kipel and Kriemhild, 2000). The growing period of wheat lasts approximately 90 days and requires little attention other than a period of dry, sunny weather (Katz, 2003). On the other hand, both the quality and the content of the wheat protein are affected by the climatic conditions during wheat Maturation (Abboud and Charles, 2012). Wheat is a principal cereal used for bread making, because of its wheat-baking properties, as well as its valuable chemical constitution. Nowadays, the quality of raw material is the most important problem for bakers. However, dough from durum wheat has higher extensibility, and more easily stretched into long pieces without breaking, making them ideal to use in pasta. In contrast, dough made from bread wheat has higher elasticity, which helps them bounce back when kneaded, making it a better choice when making bread. They require flour, which has the ability to produce bread with large loaf volume and good crumb texture, with good maintenance properties. Research on determining relationships between the flour properties and the characteristics of the final product remain a challenge for scientists. Bread properties are very often influenced by flour components (Dowell *et al.*, 2008, Edwards *et al.*, 2007, Perez Borlaet *al.*,

2004) and the rheological properties of the dough. Attempts have been made by other researchers to improve the cultivation of wheat crops grown locally in Nigeria. Mixolab mixes the dough at different temperatures, allowing the study of the dough mixing properties, weakening, gelatinization, gel stability and retrogradation in one test. The objectives of this study were to determine the proximate composition, physical properties and to predict rheological properties and bread making quality of local wheat.

Materials and methods

Five improved wheat varieties (Gerardo, Altar, Guayacan, Ranco and Plata), were cleaned, sorted, conditioned and milled into flour using laboratory milling machine. The proximate composition of the grains moisture, protein, crude fat, crude fibre, ash and starch content were adopted by (AOAC, 2000) standard method of analysis. Bulk density determination as described by Onwuka (2005). The grains length, width and thickness were determined using Buhler lens measurement equipment. Mixolab was determined using mixolab device. All determinations were done in duplicate and replicated thrice, and data collected were analyzed using statistics version 8.0 for windows.

Results and Discussion

There were variations ($P < 0.05$) of proximate composition, physical properties and mixolab indices of the five durum wheat grains and flours (Table 1). The moisture, protein, fat, ash, crude fibre and carbohydrate contents ranged from 10.85 to 11.90, 13.85 to 14.40, 1.20 to 1.46, 0.80 to 0.88, 1.28 to 1.38 and 72.55 to 72.93%, respectively, which is in line with Oberoi et al (2007). The 1000 kernel weight ranged from 37.00 to 39.20g, bulk density 0.80 to 0.82g/ml, length 6.10 to 6.90, width 3.23 to 3.83 and thickness 2.69 to 2.80mm. Water absorption capacity ranged from 8.50 to 9.00%, There was significant difference ($p > 0.05$) in the mean water absorption capacity. It was found that increase in temperature caused an increase in the movement of the flour molecules, thereby allowing more molecules to be dispersed in the solvent (Gbadamosi and Oladeji, 2013). The higher WAC of flour could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in the flour. Mixing 2.50 to 3.00 mins, gluten ranged from 7.50 to 8.00% and viscosity from 5.85 to 7.00Ns/m². It was observed that the dough of the flours obtained characterized the rheological behavior and pasting properties of flour and water dough, starch and water mixtures when subjected to the simultaneous action and mixing, which helps to adjust dough mixing parameters.

Conclusion

The wheat grains Gerardo, Altar, Ranco, Plata and Guayacan had significantly higher gluten and their range of chemical composition were within the specific range. And from the mixolab indices showed that the wheat grains are good for the production of pasta, spaghetti and other local wheat products such as alkaki and guras.

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PHYSICAL AND COOKING PROPERTIES OF IJAGULA RICE ASSERTION, A LOCALLY RED PIGMENTED LOCAL RICE CONSUMED IN IBAJI LOCAL GOVERNMENT AREA OF KOGI STATE, NIGERIA

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ABSTRACT

Physical properties of Ijagula red rice assertion, a locally consumed red rice in Ibaji Local government Area of Kogi State was carried out. The weight per 1000 paddy, paddy length, thickness, elongation ratio, cooking time and bulk density were conducted on the rice samples. Results obtained shows the weight per 1000 paddy of Ijagula rice was 32.873 g, the length of the Ijagula rice was found to be 9.073 ± 0.347 and cooking time was 28.233 ± 0.524 minutes. Furthermore, the bulk density of the Ijagula rice was found to be 0.910 ± 0.010 while the elongation ratio of the Ijagula rice was 1.730 ± 0.010 . These results obtained could depict the prospect of the Ijagula rice assertion as a promising rice worthy of exploration.

Keywords: Ijagula, physical properties, pigmented rice

1.0 INTRODUCTION

Over half of the world's population consumes rice as a staple meal (World Rice Production, 2019). Meeting the need for future rice supplies for the world's rising population, which is expected to reach 9.7 billion by 2050, is critical in maintaining food and nutritional security. Rice consumption in Sub-Saharan Africa is expected to increase from 27–28 MT per year to about 36 Mt by the end of 2026 (Terungwa and Yuguda, 2014), replacing part of the present demand for cassava, yam, maize, millet, and sorghum.

Pigmented rice consists primarily of black, red, and dark purple rice with dark red, dark purple, dark blue, red brown, black purple, or dark red-purple grains. It contains flavones, tannin, phenolics, sterols, tocopherols, -oryzanols, amino acids, and essential oils among other things (Nakornriab *et al.*, 2008; Min *et al.*, 2009). Anthocyanins, a class of reddish to purple water-soluble flavonoids, are thought to be the primary functional constituents of pigmented rice (Zhang *et al.*, 2006). Pigmented rice has long been consumed in China, Japan, and Korea, and is widely known as enriched rice for taste and health benefits (Simmons and Williams, 1997).

Red rice is a common favorite, especially among the regular white rice eaters that are looking for a much healthier alternative. Red rice is, after all, one of the purest and the richest in some of the essential nutrients that are needed for the body. Red rice are types of rice with a red bran layer. Despite the fact that the color is limited to the bran layer, a tinge of red remains even after extensive milling. The bran ranges in color from light to dark red. Red rice has 7g of protein per 100g, 5.5mg of iron, 3.3mg of zinc, and 2g of fiber per 100g. FAO (2004) reports that red rice has a higher nutritional value than milled or polished rice. Red rice is rich in magnesium. Magnesium is a crucial element in the body's control of blood pressure and salt balance against hypertension and also helps to avoid heart attacks. Red rice is also rich in fiber which can help maintain good bowel and metabolic function. Red rice contains anthocyanins, which have characteristics that can aid in weight loss. Red rice contains proanthocyanidins, which protect against type 2 diabetes, proanthocyanidins-

modulated inflammatory responses in red rice, also protect against cardiovascular disease (Priya *et al.*, 2019).

Ijagula rice assertion is a red rice popularly consumed by the people of Ibaji Local government Area of Kogi State. *Ijagula* rice assertion can either be utilized as parboiled or unparboiled cooked rice. *Ijagula* rice can be milled to flour and prepared as solid bolus food. This *Ijagula* rice assertion has been underutilized due to lack of information on its quality attributes and properties. Consumers usually use whiteness of rice as means of selecting rice variety hence the underutilization of *Ijagula* rice assertion. The aim of this paper is to evaluate the physical and cooking properties of the *Ijagula* rice assertion.

2.0 Materials and Methods

Materials: The *Ijagula* rice was obtained from JK Omonu Farms in Anocha, Ibaji Local Government Area of Kogi State, Nigeria.

Sample Preparation: Prior to experiments, the un-parboiled paddy samples were cleaned and flawed grains removed and allowed to equilibrate for 7 days. The paddy rice was soaked in water and allowed to stay in the water at 37°C for 6 hours and then heated at the temperature of 75°C for about 1 hour. The heat was removed and the paddy red rice allowed inside the water for 12 hours for the paddy to absorb water and become moisture saturated. The soaked paddy was steamed in a pot with little water enough to generate the needed steam. The pot containing the steamed rice was heated at 100°C for 15 minutes until the steam circulates the entire content. The steam was made to reach all sections of the pot by covering with jute sacks and polythene sheets. The steamed rice was then discharged, spread on dryers and sundried for 5 hours to a moisture content of 14.5%. The dried paddy rice was milled using an abrasive mill (Model: THU35B Satake testing rice husker Satake, Japan) to obtain the samples and packaged in bags.

2.1 Physical and Cooking Properties Measurements

2.1.1 Elongation ratio (Er)

The elongation ratio was calculated by selecting twenty cooked rice samples at random and measuring their length. The average length of cooked rice was divided by the average length of uncooked raw samples. Equation 1 was used to express the elongation ratio.

$$E_r = L_2 / L_1 \quad \text{Equation 1}$$

Where:

L1 = length of uncooked grain

L2 = length of cooked grain

2.2.2 Weight per thousand paddy (g)

A thousand paddy sample of each variety was chosen at random, weighed, and recorded separately to produce the thousand paddy weight (Varnamkhastiet *et al.*, 2008).

2.2.3 Paddy Length and Thickness

The length and width of the various samples were measured using a vernier caliper (Model AD-5765-100) to determine the length and thickness of the milled grain.

2.2.4 Bulk Density

A known mass (g) of the grains was measured and poured into cylinder and the volume (cm³) recorded (Sanusiet *et al.*, 2017). The bulk density was obtained using the equation 2;

$$\text{Bulk Density} = \frac{\text{Mass of Grains}}{\text{Total Volume}}$$

Equation 2

2.2.5 Cooking Time

Milled rice weighing 10 g from each sample were cooked in 100 ml of water at 100°C on an electric cooker (Toshiba, Model RC18R). After cooking for 10 minutes, 10 grains were taken every 2 minutes for testing until the cooking cycle was completed. Ten cooked grains were chosen at random and placed between two clean glass plates. Each variety's cooking time was recorded when until when the grains no longer had an opaque core or uncooked centers.

2.2.6 Statistical Analysis

Results obtained were subjected to statistical analysis (mean and standard deviation) using SPSS (2020) version.

3.1 Results and Discussion

Table 3.1: Cooking and Physical Properties of Ijagula rice Assertion

Weight per 1000 paddy (g)	Length (mm)	Thickness (mm)	Cooking Time (min)	Bulk Density (g/mL)	Elongation Ratio
32.873±0.669	9.073±0.347	1.517±0.106	28.233±0.524	0.910±0.010	1.730±0.010

Values represent means and standard deviation of triplicate determinations.

As shown in Table 1, the weight per 1000 paddy of Ijagula rice was 32.873 (g). This value greatly depends on the amount of fully mature and immature grains available among the grains counted. Moisture available in the grains could also be responsible for the variation in weight of the rice samples. Falade and Christopher (2015) reported 25.99 ± 0.31 for Farro44. Ponnapan *et al.* (2017) reported 20.80 ± 0.03 (g) for TPS-1 red rice variety and 19.82 ± 0.04 (g) for TKM-9 red rice as well.

In terms of length, the length of the Ijagula rice was found to be 9.073 ± 0.347 (mm). Sanusi *et al.* (2017), reported that the length of Farro 44 was 8.99 ± 0.60 (mm) and attributed their differences in dimension to individual property. Also, 5.13 and 5.38 mm was also reported for TPS-1 and TKM-9 red rice varieties (Ponnapan *et al.*, 2017). The length, width, and thickness of the varieties are critical in the design and selection of sieve separators, as well as in calculating power during rice milling (Varnamkhastiet *al.*, 2008).

The cooking time of the Ijagula was 28.23 ± 0.524 (min) as shown in Table 1. The cooking time was way higher than the value of 21.50 ± 1.54 (min) reported by Sanusi *et al.* (2017) for Farro 44 rice. However, Ziegler *et al.* (2017), reported 32.6 (min) for red rice. The cooking time of rice is greatly influenced by the gelatinization temperature. A higher gelatinization temperature connotes a high cooking time (Sanusi *et al.*, 2017). Cooking time is also related to amylose content as amylose acts as a diluent as well as inhibitor to swelling of starch (Bhat and Rair, 2016). The thickness of the grain appears to have a significant effect on

cooking time, possibly due to faster moisture diffusion in grains of smaller thickness (Mohapatra and Bal, 2006).

The bulk density of the Ijagula rice was found to be 0.910 ± 0.010 . This is probably due to the individual inherent properties of the various rice types. The study of bulk density helps in the design and fabrication of storage facilities and equipment (Sanusiet *al.*, 2017).

The elongation ratio of the Ijagula rice is 1.730 ± 0.010 . Elongation ratio is an important factor in determining the cooking quality of rice grains. Kernel elongation is a physical phenomenon that is influenced by a variety of physicochemical and genetic factors such as genotypes, aging temperature, aging time, water uptake, amylose content, and gelatinization temperature (Golam and Prodhan, 2013).

3.2 Conclusion

The findings from the physical and cooking properties of Ijagula rice assertion will aid in the selection of appropriate milling and storage equipment, as well as their use in the food system. Furthermore, the results show a long cooking time, which could be due to other factors, necessitating further investigation.

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IMPACT OF GERMINATED BAMBARA GROUNDNUT FLOUR ADDITION ON THE *IN VITRO* DIGESTIBILITY AND MINERAL COMPOSITION OF WHEAT FLOUR

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Abstract

The impact of addition of different proportions (5, 10, 15, 20, 25 and 30% w/w) of germinated Bambara groundnut flour (GBF) on the *in vitro* starch and protein digestibility as well as mineral composition of wheat flour (WF) was investigated. Results obtained revealed that WF substituted with 30% GBF had the highest *in vitro* protein digestibility (IVPD, 80.19%), resistant starch (RS, 29.85%), slowly digestible starch (SDS, 28.74%) and lowest rapidly digestible starch (RDS, 43.69%) compared to 100 % WF (72.03% IVPD, 20.66% RS, 26.24% SDS and 53.10% RDS). Substitution of WF with 5-30% GBF significantly ($p \leq 0.05$) increased calcium, iron, magnesium, phosphorus, potassium and zinc by 1.30 to 5.81%, 63.31 to 214.39%, 3.57 to 8.30%, 1.69 to 17.93%, 35.41 to 100.17% and 8.15 to 45.95%, respectively, compared to 100% WF. The results demonstrated that substitution of WF with GBF could serve as a low-cost approach to improve the digestibility and mineral composition of wheat-based formulation.

Keywords: Germinated Bambara groundnut, Starch fractions, Protein digestibility, Mineral constituents

1.0 Introduction

Wheat (*Triticum aestivum* L.) is a nutritionally important cereal consumed throughout the world. Wheat is used in the production of flour, malt, beer, and several food products such as bread, pasta, breakfast cereals, biscuits, cakes, extruded snacks, among others. Wheat production is limited in most regions of the world including Africa. This is because the unfavorable climatic conditions in these regions do not support wheat cultivation and thus, led to high cost of wheat importation in non-wheat producing countries. This situation also exerts pressure on the country's food import bill and foreign exchange. This has partly stimulated research on the inclusion of alternative crops as substitute to reduce over-dependence on wheat flour importation which has depleted foreign reserves of non-wheat producing countries.

On the other hand, there is an increasing consumer demand for wheat-based bakery foods containing functional ingredients in order to increase nutrient density (including high-quality protein), micronutrients and bioactive compounds, to mitigate the burden of nutritional deficiencies and promote consumer health (Chinma *et al.*, 2020). A low-cost approach to improve the nutritional quality of bakery foods is the inclusion of cheap and readily available nutrient-dense functional ingredients because refined wheat flour contains relatively

low protein content, micronutrients, bioactive constituents and has high glycemic index (Buokid *et al.*, 2019).

Bioprocessed legume flour is a functional ingredient with improved functional characteristics, rich in protein, dietary fiber, micronutrients, bioactive compounds, low starch digestibility and residual antinutrients for diverse food applications (Chinma *et al.*, 2021a). Several studies have established that germination improved the functionality of legume seeds such as lentil (Polat *et al.*, 2020), Bambara groundnut (Chinma *et al.*, 2021a), African yam bean (Chinma *et al.*, 2021b), chickpea (Yaver, 2022) and pigeon pea (Chinma *et al.*, 2022). Germinated Bambara groundnut flour has improved nutritional, nutrient digestibility, techno- and bio-functional properties (Chinma *et al.*, 2021a) for fortification of wheat flour. However, there is limited information on the *in vitro* starch and protein digestibility, and mineral composition of WF-GBF blends. It can be hypothesized that substitution of WF with GBF can modify the starch fractions, protein digestibility and mineral composition of the blends for improved nutrition. The objective of the study was thus, to evaluate the *in vitro* starch and protein digestibility, as well as mineral composition of WF and GBF blends.

2.0 Materials and Methods

2.1 Materials

Wheat flour (*Triticum aestivum* L., Golden Penny Plc., Lagos, Nigeria) and Bambara groundnut (*Vigna subterranean*, brown variety) seeds were procured from Central market Minna, Nigeria. The wheat flour (WF) was profiled using standard analytical methods and contained 9.23 g/100 g moisture, 12.18 g/100 g protein, 0.69 g/100g ash, 0.31 g/100 g insoluble dietary fiber (IDF), 1.93 g/100 g soluble dietary fiber (SDF), 2.24 g/100 g total dietary fiber (TDF), 68.52 g/100 g total starch (TS) and 0.52 mg GAE/g total phenolic content (TPC).

2.2. Preparation of germinated Bambara groundnut flour (GBF)

The GBF was prepared from cleaned Bambara groundnut (BGN) seeds as described by Chinma *et al.* (2021a). The BGN seeds (250 g) were steeped in distilled water (1000 mL for 6 h) before the water was drained and the seeds were spread out on a clean stainless tray. The hydrated BGN seeds were germinated at 28 ± 1 °C for 72 h. Three batches of the 72-h germinated BGN seeds were prepared. Afterwards, the seeds were oven dried (Model TI2h, Genlab, Cheshire, U.K.) at 40 °C for 24 h, milled using a hammer mill (Brook Crompton Series 2000, Christy Hunt Agriculture Ltd., South Humberside, England), and sieved (through a 100 mm screen). The composition of the 72 h GBF profiled using standard methods, included 8.23 g/100 g moisture, 4.08 g/100 g ash, 26.1 g/100 g protein, 7.73 g/100 g fat, 2.88 g/100 g SDF, 10.41 g/100 g IDF, 13.29 g/100 g TDF, 43.53 g/100 g TS 4.75 mg/100 g phytic acid (PA) and 1.15 g/100 g TPC (Chinma *et al.*, 2021a).

2.3 Formulation of blends

Flour blends were prepared by using GBF to replace WF at graded levels (w/w) of 0, 5, 10, 15, 20, 25 and 30%. A blender (BLX750RD, Kenwood, Sheffield, UK) was used to uniformly blend the composite flours and separately packaged in a plastic container with lids, prior to analysis.

2.4 Analysis of flour blends

The *in vitro* starch digestibility of samples was analyzed following the method detailed in our earlier study (Chinma *et al.*, 2021a). This involved evaluation of starch fractions (rapidly

digested starch (RDS), slowly digestible starch (SDS) and resistant starch (RS)) after the hydrolysis of samples with glucose oxidase-peroxidase (Megazyme kit, Bray, Ireland). The percentage of RDS, SDS, and RS was calculated using Equation 1.

$$RS (\%) = [(TS - RDS - SDS) / TS] \times 100 \quad (1)$$

In vitro protein digestibility was determined following a method detailed in a previous study by Chinma *et al.* (2021a). Briefly, sample (200 mg) was placed in 100 mL Erlenmeyer flask (containing 35 mL of 0.1 mol/L sodium citrate tribasic dihydrate at pH 2.0 and 1.5 g/L pepsin). The mixture was incubated (at 37 °C for 2 h), centrifuged (15 min, 10000 × g) and the supernatant was decanted. Afterwards, the residue was washed, dried and analyzed for nitrogen value following a standard procedure. The percentage IVPD of the samples was calculated using Equation 2.

$$IVPD = \frac{(\text{total nitrogen} - \text{residue nitrogen}) \times 100\%}{\text{total nitrogen}} \quad (2)$$

Mineral content was determined by inductively coupled plasma-optical emission spectrometry described by Zarcinas *et al.* (1987) and analyzed for calcium (Ca), iron (Fe), magnesium (Mg), phosphorus (P), potassium (K) and zinc (Zn). Subsequent values were expressed as mg/100 g.

2.5 Statistical analysis

Statistical analysis was carried out on all the data obtained using analysis of variance (ANOVA) SPSS 20 (IBM, Armonk, NY, USA) and Tukey's test was used to determine significant differences (5% probability) among means.

3.0 Results and Discussion

3.1 *In vitro* starch and protein digestibility wheat-GBF flour blends

The RS, RDS and SDS contents of the 100% wheat flour were 53.10%, 26.2% and 20.66%, respectively (Table 1). Substitution of WF with GBF significantly ($p \leq 0.05$) decreased RDS value. In contrast, RS and SDS significantly increased with increasing level of GBF. The decreased starch hydrolysis in the WF-GBF blends may be ascribed to starch dilution by other constituents such as dietary fiber and polyphenols from GBF, which inhibited starch hydrolysis by blocking the interaction between starch and the enzymes (Zhu, 2015). In addition, presence of RS, protein and fat provided physical barrier on the starch granule against degradation by enzyme. High contents of RS and SDS have nutritional benefits (Chinma *et al.*, 2021a). The IVPD of the composite flours were significantly higher than 100% WF. This increase may be partly ascribed to lower starch digestibility. In addition, the inclusion of GBF rich in lysine (Chinma *et al.*, 2021a) probably increased IVPD. The low starch digestibility and high IVPD values recorded in the composite blends as compared to 100% WF is indicative of improved nutritional value of the blends for the formulation of functional foods.

3.2 Mineral composition of wheat-GBF flour blends

Substitution of WF with 5-30% GBF significantly ($p \leq 0.05$) increased Ca, Fe, Mg, P, K, and Zn contents by 1.30-5.81%, 63.31-214.39%, 3.57-8.30%, 1.69-17.93%, 35.41-100.17% and 8.15-45.95%, respectively, compared to 100% WF. The observed increase in mineral content of flours substituted with GBF could be attributed to the fact that germi-

nated legumes are rich sources of micronutrients. This implies that flour samples containing GBF would contribute to mineral intake of consumers. Minerals play significant role in the physiological activities of humans. These results are in agreement with the report of Chinma *et al.* (2012) where inclusion of germinated tigernut and *moringa* seeds improved the mineral composition of wheat flour.

4.0 Conclusions

Results obtained in this study demonstrated that addition of germinated Bambara groundnut flour improved starch and protein digestibility as well as mineral constituents of the composite flours than 100% wheat flour. Composite blends containing 30% GBF had the highest protein digestibility, resistant starch, slowly digestible starch and mineral content. The inclusion of GBF in wheat-based composite for product development is recommended considering their improved digestibility and mineral composition. In the light of this, studies are on-going in our laboratory on the effect of substitution of GBF on the physicochemical, nutritional and sensory properties of wheat bread.

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Table 1: *In vitro* starch and protein digestibility of wheat flour substituted with germinated Bambara groundnut flour

Samples	100WF	95WF: 5GBF	90WF: 10GBF	85WF: 15GBF	80WF: 20GBF	75WF: 25GBF	70WF: 30GBF
Rapidly digestible starch (%)	53.10±0.16 ^a	49.06±0.11 ^b	46.39±0.13 ^c	45.10±0.07 ^d	43.69±0.09 ^e	42.53±0.11 ^f	41.68±0.14 ^g
Slowly digested starch (%)	26.24±0.05 ^f	25.83±0.02 ^g	26.50±0.07 ^e	27.32±0.11 ^d	27.91±0.05 ^c	28.36±0.03 ^b	28.74±0.07 ^a
Resistant starch (%)	20.66±0.02 ^g	25.11±0.07 ^f	27.11±0.03 ^e	27.58±0.05 ^d	28.40±0.03 ^c	29.11±0.05 ^b	29.85±0.13 ^a
<i>In vitro</i> protein digestibility (%)	72.05±0.11 ^g	73.42±0.03 ^f	74.20±0.07 ^e	76.61±0.11 ^d	77.35±0.11 ^c	78.60±0.14 ^b	80.19±0.10 ^a

The data from triplicate experiments are expressed as a mean ± standard deviation. Values with different superscripts in a row are significantly different ($p \leq 0.05$). 100WF = 100% wheat flour (control sample); 95WF:5GBF = 95% wheat flour : 5% Germinated Bambara groundnut flour, 90WF:10GBF = 90% wheat flour : 10% Germinated Bambara groundnut flour; 85WF:15GBF = 85% wheat flour : 15% Germinated Bambara groundnut flour; 80WF:20GBF = 80% wheat flour : 20% Germinated Bambara groundnut flour; 75WF:25GBF = 75% wheat flour : 25% Germinated Bambara groundnut flour, and 70WF:30GBF = 70% wheat flour : 30% Germinated Bambara groundnut flour.

Table 2: Mineral composition of wheat flour substituted with germinated Bambara groundnut flour

Samples	100WF	95WF: 5GBF	90WF: 10GBF	85WF: 15GBF	80WF: 20GBF	75WF: 25GBF	70WF: 30GBF
Calcium (mg/ 100 g)	163.17±0.20 ^g	165.29±0.20 ^f	168.10±0.21 ^e	169.64±0.15 ^d	170.80±0.22 ^c	171.43±0.17 ^b	172.65±0.16 ^a
Iron (mg/ 100 g)	1.39±0.03 ^g	2.27±0.02 ^f	2.52±0.01 ^e	2.87±0.01 ^d	3.23±0.04 ^c	3.80±0.01 ^b	4.37±0.01 ^a
Magnesium (mg/ 100 g)	44.60±0.11 ^g	46.19±0.16 ^f	41.17±0.23 ^e	43.32±0.26 ^d	44.55±0.10 ^c	46.52±0.13 ^b	48.30±0.29 ^a
Phosphorus (mg/100 g)	348.92±0.16 ^g	354.81±0.15 ^f	362.45±0.27 ^e	375.60±0.18 ^d	389.73±0.14 ^c	397.29±0.21 ^b	411.48±0.12 ^a
Potassium (mg/100 g)	194.56±0.37 ^g	263.46±0.25 ^f	295.70±0.33 ^e	327.12±0.20 ^d	342.46±0.27 ^c	366.58±0.19 ^b	389.46±0.22 ^a
Zinc (mg/100 g)	1.35±0.01 ^f	1.46±0.01 ^e	1.55±0.00 ^d	1.69±0.01 ^c	1.77±0.01 ^b	1.92±0.01 ^a	1.97±0.01 ^a

The data from triplicate experiments are expressed as a mean ± standard deviation. Values with different superscripts in a row are significantly different ($p \leq 0.05$). 100WF = 100% wheat flour (control sample); 95WF:5GBF = 95% wheat flour: 5% Germinated Bambara groundnut flour, 90WF:10GBF = 90% wheat flour: 10% Germinated Bambara groundnut flour; 85WF:15GBF = 85% wheat flour: 15% Germinated Bambara groundnut flour; 80WF:20GBF = 80% wheat flour: 20% Germinated Bambara groundnut flour; 75WF:25GBF = 75% wheat flour: 25% Germinated Bambara groundnut flour, and 70WF:30GBF = 70% wheat flour: 30% Germinated Bambara groundnut flour.

QUANTIFICATION OF PHENOLIC COMPOUNDS IN MAIZE SOURDOUGH

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Abstract

This study investigated the pH, titratable acidity (TTA) and phenolic compounds of fermented (24–72 h) maize flour into sourdough. The pH of the sourdough sample decreased significantly ($p \leq 0.05$) after 72 h fermentation while there was an increase in TTA over time except for a decrease at the end of fermentation period. Eight phenolic compounds were quantified and they were classified into phenolic acids (gallic, sinapic, vanillic, ferulic, caffeic and *p*-coumaric acids) and flavonoids (taxifolin, apigenin and luteolin). In this study, gallic, vanillic, ferulic and caffeic acids were not detected in the unfermented and fermented sourdough. Although, *p*-Coumaric acid was only detected in the 48 h sourdough sample and sinapic acid was only detected in the sourdough fermented at 24 h. All the investigated flavonoids in this study were detected, except for apigenin which was not detected at the initial fermentation stage and taxifolin which was not detected after 72 h of fermentation. The notable flavonoids in this study position the sourdough to potentially possess health beneficial properties, as these flavonoids (taxifolin, apigenin and luteolin) are known to have anti-inflammatory and anti-cancer properties. Considering the available phenolic compounds in the samples, the maize sourdough could also be considered for inclusion in other products.

Keywords *Zea mays*, Fermented product, Phenolic acids, UHPLC-DA

3.0 Introduction

Maize (*Zea mays*) also known as corn is the most widely cultivated and diverse cereal crops in many parts of the world after rice and wheat (Hossain *et al.*, 2019). Maize, though not as commonly consumed as rice and wheat is an excellent source of nutraceuticals known to increase health and prevent diseases. Each country, especially in Africa have different forms and ways of consuming maize and examples include as snacks, beverages, porridges, bread and can also be eaten either as boiled or roasted (i.e., mature or immature whole kernel) as well as milled into flour for traditional products (Ekpa *et al.*, 2019). However, in West Africa for example Nigeria, the most common form of consuming maize is into sourdough where more than half of the entire maize production is used for *ogi* (Steinkraus, 2004). The sourdough is either produced from dried or fresh maize as its preparation usually takes about 4–6 days which is time consuming and labor intensive (Ekpa *et al.*, 2019). However, higher temperature, the use of dried maize flour and pure starter cultures are the technological advancements that have shown

positive outcomes in decreasing sourdough preparation time and enabling industrial processes (De Vuyst *et al.*, 2021).

The conventional sourdough preparation also involves the use of natural fermentation (uncontrolled) but backslapping is sometimes used to attain a faster and consistent fermentation process (Nout, 2009). Natural fermentation is brought about by the sequential and competitive action of a plethora of microorganisms, with the best adapted strain(s), having a better growth rate, eventually dominating the fermenting microbiota (Adebo, 2020). For backslapping, this involves the inoculation of a previous successful fermentation batch into a new process, a procedure which guarantees a better fermentation process (Adebo, 2020). Fermentation for the production of sourdough has been done for ages and during this process are subsequent improvement in organoleptic properties and nutritional constituents. Considering the consequent impact of fermentation on health promoting components and the notion that fermented foods could be consumed as functional foods, it is vital to study health-related components in sourdough. Hence, this study was aimed at investigating the phenolic compounds in maize sourdough produced at different fermentation times as well monitoring the pH and titratable acidity.

2.0 Materials and Methods

2.1 Materials and sample preparation

Maize (*Zea mays*) grains were purchased from the Agricultural Research Council (Grain Crops, Potchefstroom, South Africa). The grains were milled into flour using the method of Adebo *et al.* (2021) and mixed with distilled water (1:1 v/w). The mixture was then incubated at 35 °C (Incotherm, Labotec, Johannesburg, South Africa) for different fermentation period (0, 24, 48 and 72 h) to obtain sourdough, following natural (spontaneous) fermentation.

2.2 pH and TTA (titratable acidity)

The pH and TTA (titratable acidity) are measured following the procedure described in Adebo *et al.* (2021) while for the TTA, 10 g of each sample was mixed with 90 mL of distilled water, with the mixture being allowed to rest to obtain the supernatant. The supernatant was then titrated against 0.1 M NaOH.

2.3 Quantification of Phenolic Compounds

Phenolic compounds were extracted from the raw maize and the fermented sourdough and quantified using a modified method of Adebo *et al.* (2021). Briefly, 0.25 g of samples, and 5 mL of acidified methanol (1% HCl in 80% aqueous methanol) was added in an Eppendorf tube and the mixture was sonicated in an ultrasonic bath (AU 220, Argo Lab, Carpi, Italy) for 1 h. The mixture was then centrifuged at $2100 \times g$ at 4 °C for 10 min using an Eppendorf 5702R centrifuge (Merck, Germiston, South Africa). The supernatant obtained was evaporated in a vacuum evaporator (Eppendorf Vacuum Concentrator Plus, Analytical Solutions, Johannesburg, South Africa) and the dried extract was reconstituted with 1 mL 50% liquid chromatographic grade methanol (Merck, Johannesburg, South Africa) and filtered into dark amber vials.

Later, quantification was done on an ultra-high pressure liquid chromatography (UHPLC) system (Shimadzu, Kyoto, Japan) equipped with a DGU-403 degassing unit, LC-40B XR binary pumps, LC-40B XR solvent delivery module, CTO-40C column oven, SIL-40C XR auto-sampler as well as an SPD-M40 diode array detector. The extracts (2 μ L) each were injected into the system and separation done on a Raptor C₁₈ column (2.7 μ m $\times$ 100 mm $\times$ 2.1 mm ID, Restek, Bellefonte, USA) at an oven temperature of 40 °C. The mobile phase A was 1% formic acid in Milli-Q water and B was 1% formic acid in a mixture of 50% methanol and acetonitrile and the total run time was 15 min.

2.4 Statistical Analysis

All analysis were conducted in triplicates and analysis of variance (ANOVA) was done using SPSS version 22 (IBM, Armonk, USA). Differences at 5 % ($p \leq 0.05$) level were considered statistically significant.

3.0 Results and Discussion

3.1 pH and TTA

The pH and titratable acidity (TTA) results is presented in Figure 1. The pH of the sourdough sample decreased significantly ($p \leq 0.05$) (comparing 0 h (6.39) – 72 h (3.58) of fermentation), while there was an increase in TTA over time, except for a decrease at the end of fermentation period. The buildup of organic acids with an increase in metabolism of the fermenting organisms and microbial activity might be linked to the decrease in TTA at the end of fermentation period (Adebo *et al.*, 2018). Also, as the pH decreased, the TTA increased which demonstrated that the sourdough is becoming more acidic in nature. Acid formation during the course of fermentation could be attributed to carbohydrate metabolism. Lactic acid bacteria (LAB) are produced during cereal (maize) fermentation therefore, reduction in pH as fermentation progressed is attributed to production of acid by LABs. Acidity and pH are of importance during the preparation of sourdough with absence of such acidity possibly causing a poorly fermented product.

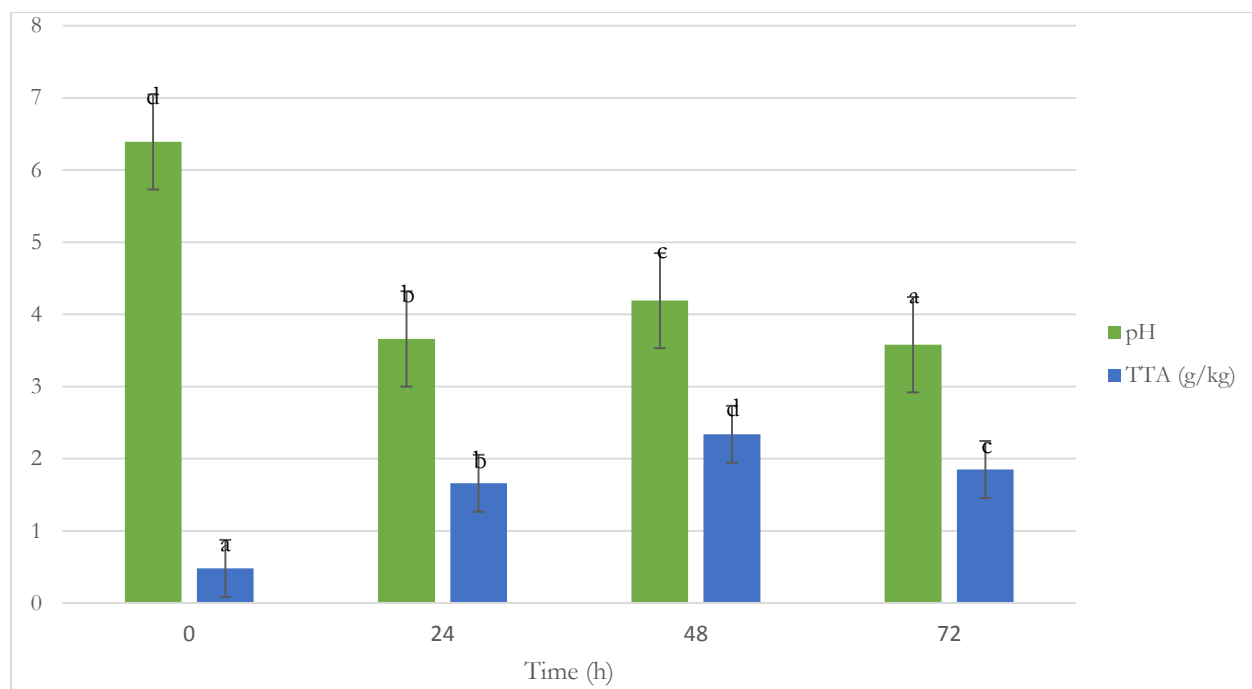


Figure 1: pH and TTA of maize sourdough during fermentation

3.2 Phenolic compounds

The presence of phenolic compounds in several plant foods promotes their unique characteristics due to their flavor as well as color. They act as defense mechanisms and exist in insoluble bound, free and soluble conjugated forms. Flavonoids, phenolic acids and tannins are the major phenolic compounds present in cereals. In this present study, eight phenolic compounds were quantified and they were classified into phenolic acids (gallic, sinapic, vanillic, ferulic, caffeic and *p*-coumaric acids) and flavonoids (taxifolin, apigenin and luteolin) (Table 1).

Table 1: Phenolic compounds ($\mu\text{g/g}$) of maize sourdough over time

Parameters	λ_{max}	0 h	24 h	48 h	72 h
	(nm)				
Luteolin	348	12.10 ^b $\pm$ 0.52	28.02 ^c $\pm$ 0.75	0.76 ^a $\pm$ 0.04	32.40 ^d $\pm$ 0.24
Ferulic acid	322	ND	ND	ND	ND
Taxifolin	290	21.21 ^b $\pm$ 0.25	31.92 ^c $\pm$ 1.56	30.69 ^c $\pm$ 0.44	0.00 ^a
Apigenin	336	0.00 ^a	1.86 ^b $\pm$ 0.18	10.29 ^d $\pm$ 0.07	3.68 ^c $\pm$ 0.23
<i>p</i> -Coumaric acid	309	0.00 ^a	0.00 ^a	6.98 ^b $\pm$ 0.86	0.00 ^a

Sinapic acid	319	0.00 ^a	2.92 ^b ± 0.26	0.00 ^a	0.00 ^a
Caffeic acid	323	ND	ND	ND	ND
Gallic acid	271	ND	ND	ND	ND
Vanillic acid	261	ND	ND	ND	ND

ND – not detected; λ – wavelength; h – hour. Each value is a mean $\pm$ standard deviation of triplicate samples (n=3). Means with no common letters within a row significantly ($p \leq 0.05$) differ.

Luteolin range from 0.76 to 32.40 $\mu\text{g/g}$ and was significantly ($p \leq 0.05$) different at each fermentation period. The lowest value for luteolin was recorded at 48 h (0.76 $\mu\text{g/g}$) fermentation period with an initial of 12.10 $\mu\text{g/g}$ and highest (32.40 $\mu\text{g/g}$) at 72 h. Luteolin have strong anticancer effects and are majorly found in fruits and vegetables as well as some cereals. Taxifolin increased in the 24 h sample and dropped slightly with no significant ($p \leq 0.05$) difference after 48 h. Taxifolin is a flavonol with anti-inflammatory and antioxidant effects as well as helpful in the cure of epidermis burns. Apigenin was not detected at the initial fermentation but later increased significantly at 24 and 48 h, but a decline was observed towards the 72 h fermentation period. The trend of increase and a decline observed in apigenin correspond with pH and TTA (Figure 1).

Phenolic acids are the derivatives of cinnamic and benzoic acids which are found in cereals while hydroxycinnamic and hydroxybenzoic acids are classes of phenolic acids. Examples of hydroxycinnamic include ferulic, sinapic, caffeic and coumaric acids which all have a C6-C3 structure. The hydroxybenzoic acid consist of syringic, gallic, vanillic, protocatechuic and *p*-hydroxybenzoic acids while both free and bound are the form of phenolic acids reported in cereals although level of phenolic acids varies in cereals (Dykes & Rooney, 2007). In Table 1, these phenolic acids; gallic, vanillic, ferulic and caffeic acids were not detected in both the unfermented and fermented sourdoughs. Caffeic and ferulic acids possibly could have been decreased or not detected by the action of phenolic acid reductase to hydroxyphenylpropionic acids, such as dihydroferulic and dihydrocaffeic acids (Apramita & Appaiah, 2018).

p-Coumaric acid was only detected in the 48 h sourdough sample likewise, sinapic acid was only detected in the sourdough fermented at 24 h (Table 1). The possibly cause for the undetected sinapic acid in the sourdough samples could be connected to sinapic acid forming dimers with itself (4-vinylsyringol which is decarboxylation product of sinapic acid). The impacts of fermentation on phenolic compounds are a factor of enzymatic activity, grain types and fermentation conditions (especially pH, time and temperature) (Dordevic *et al.*, 2010).

4.0 Conclusion

In this study, pH, titratable acidity and phenolic compounds in maize sourdough were investigated over different fermentation periods. The findings of this study show that there was a decrease in pH and increase in TTA over time while flavonoids (taxifolin, apigenin and luteolin) were detected in the fermented samples unlike the phenolic acids (gallic, sinapic, vanillic, ferulic, caffeic and *p*-coumaric acids). Phenolic acids in this study especially *p*-Coumaric and sinapic acids did not show a consistent trend during fermentation and the mechanism for this should be further investigated. However, to avoid reduction of phenolic compounds starter cultures and lower fermentation temperature could be considered.

5.0 Acknowledgment

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BIOCHEMICAL CHARACTERIZATION OF SOURDOUGH PRODUCED FROM SORGHUM (*SORGHUM BICOLOR*)

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Abstract

This study investigated the pH, titratable acidity (TTA) and organic acids (OAs) produced from sorghum sourdough at different fermentation time (0, 24, 48 and 72 h). The pH and TTA were evaluated using conventional methods, while OAs were investigated using ultra-high performance liquid chromatography (UHPLC)-diode array (DA) system. Results showed a decline in pH after 72h from 6.57 to 3.50 while a slight increase was observed at 48 h (4.10) when compared between 24 and 72 h. The TTA significantly ($p \leq 0.05$) increase from 0.34 to 1.91 g/kg with increasing days of fermentation, but a decline was observed at the end of fermentation period (72 h). Likewise, an increase in TTA was observed in the 48 h (1.91 mg/kg) sourdough as compared to 24, and 72 h samples. The UHPLC-DA data showed seven OAs including oxalic, L-ascorbic, lactic, maleic, shikimic and succinic acids. Notably, oxalic acid (138.39 - 394.90 mg/kg) and maleic acid (10.56 - 101.46 mg/kg) had the highest concentrations among all the OAs identified in each sample. L-ascorbic, lactic and succinic acids were not produced in the control sample (0 h) while the L-ascorbic acid was also not produced in the 24 h sourdough. The study can be considered as an effective means to evaluate the characterization of sourdough.

Keywords Cereal, Dough fermentation, Titratable acidity, Fermentation period.

Introduction

Foods in several forms from cereal are component vital for the daily diet. Cereals such as sorghum, maize, millet are generally not consumed in raw form but milling (dry) as well as mixing with water are employed before it can be consumed (Kent-Jones and Singh 2021). Such a mixture when left on its own for some period will result into the formation of dough (i.e. sourdough) characterized by sour aroma and this may possibly have been the first evidence of fermented food used by humans (Hammes and Ganzle, 1998; Corsetti and Settanni, 2007). The

production of sourdough processes can be classified as either a traditional classification method or inoculum-based classification.

Sourdough is used to produce products of different varieties such as crackers, breads, pizza and cakes. These products from sourdough are applied to a large selection of cereal flours (i.e. wheat, rye, barley etc) all over the world. Although, wheat and rye into sourdough are the common cereals that are of interest. Incorporation of sourdough in baking technological qualities, increases shelf life, sensorial characteristics, bioactive compounds and enhances nutritional properties (Limbadet *et al.*, 2020). However, in dough rheology, influence of changes must be taken into consideration in order to select suitable fermentation time and obtain product of good quality (Apleviczet *et al.*, 2013). In addition, flour type and sourdough fermentation conditions (temperature and pH) are other factors to be taken into consideration. Hence, this study was aimed to produce sourdough from sorghum flour using different fermentation time and determine its effect on pH, titratable acidity and organic acids.

Materials and Methods

Materials

Sorghum (*Sorghum bicolor*) was procured from a local market in Johannesburg, South Africa. The sorghum grains were cleaned to remove stone, and other foreign object while the grains were milled with a Perten Laboratory Mill 3310 (Perten Instruments AB, Helsinki, Finland) as well as sieve (Analysette 3 Spartan, Fritsch, Germany) through a 1 mm aperture size to obtain sorghum flour.

Fermentation of sourdough from sorghum flour

The milled sorghum flour was processed into sourdough where the flour was mixed with distilled water (1:1, v/w). The mixture (flour and water) was incubated (using Incoterm, Labotec, Johannesburg, South Africa) at 35°C and separately fermented for 24, 48, and 72 h. The fermentation process done at each time was performed in triplicates.

pH and Titratable Acidity (TTA)

The pH of the fermented sourdough was measured using a portable pH meter (Hanna Instruments (Pty) Ltd., Johannesburg, South Africa). For titratable acidity (TTA), 10 g of each sample was mixed in 90 mL of sterile distilled water. The mixture was being allowed to rest in order to obtain the supernatant. Afterward, the supernatant was titrated against 0.1 M sodium hydroxide.

Extraction and concentration of organic acids

According to the method of Tang *et al.* (2015), 1 g of sourdough sample was extracted with 15 mL of 0.02 mol/L NaH₂PO₄ (pH 2.7) and centrifuged (at 6800 g for 10 min). The supernatant (1 mL) obtained was diluted (1:6 v/v) with 0.02 mol/L NaH₂PO₄ (pH 2.7) and filtered

(0.22 µm) into amber vials. An ultra-high performance liquid chromatograph (UHPLC) connected with SIL-40R XR autosampler, DGU- 403 degassing unit, LC-403B XR solvent delivery module, and an SPD-M40 photodiode array detector, CTO-40C column oven (30 °C). Isocratic mobile phase (0.02 mol/L NaH₂PO₄, pH 2.7) was adopted with a flow rate of 0.25 mL/min, injection volume (10 µL) and an acquisition time of 13 min.

Statistical Analysis

All analysis were conducted in triplicates and analysis of variance (ANOVA) was done using SPSS version 22 (IBM, Armonk, USA). Differences at 5 % ($p \leq 0.05$) level were considered statistically significant.

Results and Discussion

The pH and titratable acidity (TTA) values of the sourdough samples fermented at different times are shown in Table 1. The initial pH value of the dough was 6.57 and declined with longer fermentation time (72 h) to 3.50. During sourdough fermentation, enzymes present in dough system effect the change in pH value (Clarke *et al.*, 2004). The decline in pH value could also be linked to organic acids which could have possibly exerted an effect on the behavior of viscoelastic of the dough (Wehrle and Arendt, 1998).

The TTA on the other hand, significantly ($p \leq 0.05$) increased from 0.34 to 1.91 g/kg with increasing fermentation time, but a decline was observed at the end of fermentation period (72 h). The decrease in TTA at longer fermentation time was probably due to the fermenting microorganisms which were earlier present and might have entered their decline phase and causing a decrease in microbial activity. However, the rate of acidification of the sourdough was faster and this became obvious by the pH and TTA values obtained in 48 h. Additionally, environmental conditions (temperature and pH) in the sourdough may speed up the flour amylases and improved the fermentable sugars particularly maltose and this would concurrently increase production of acid and further decrease pH (Galal *et al.*, 1978).

Table 2 shows the different organic acids (OAs) produced in the sourdough over the fermentation periods. The 72 h sourdough yielded significantly ($p \leq 0.05$) the highest oxalic acid content (394.90 mg/kg) followed by the sourdough produced at 48 h (278.36 mg/kg). Likewise, the 72 h sourdough also had the highest maleic acid content (101.46 mg/kg) followed by the sourdough produced at 48 h (92.15 mg/kg). This shows the production of oxalic and maleic acids significantly ($p \leq 0.05$) increase with an increase in fermentation time.

In fermented cereals, the production of OAs is mainly ascribed to the presence of homo- and hetero-fermentative lactic acid bacteria. The L-ascorbic, lactic, and succinic acids were not produced in the 0 h sourdough while the L-ascorbic acid was not produced in the 24 h sourdough (Table 2). Additionally, lactic acid was also not produced in the 48 h and 72 h sourdoughs. The production of lactic acid in this study (Table 2) could be attributed to actions of lactic acid bacteria, but subsequent reduction after 48 h and onwards could be ascribed to possible use

up of lactic acid for metabolic processes and as substrates for aroma-related compounds. During fermentation, the produced OAs affect pH, acidity, and/or flavor of fermented foods, and influence organoleptic properties directly. The state of raw materials, types of microorganisms, fermentation environment and methods are factors that can influence the ratio of the contents of OAs (Choi *et al.*, 2007).

Conclusion

This study provides an insight into the biochemical changes of sourdough produced from sorghum at different fermentation time. Variations were observed in some of the organic acid during fermentation time. In order to understand the fermentation profile, additional detailed work is required to identify the effect of pH, TTA, organic acids and other parameters on the final product from sorghum sourdough with the use of certain or new lactic acid bacteria and yeasts for enhancing the performance and/or for targeting certain qualities.

Table 1: pH and TTA of sourdoughs from sorghum fermented at different fermentation periods

Parameters	0	24 h	48 h	72 h
pH	6.57 ^d ± 0.02	3.53 ^b ± 0.01	4.10 ^c ± 0	3.50 ^a ± 0.01
TTA (g/kg)	0.34 ^a ± 0.01	1.35 ^b ± 0.03	1.91 ^d ± 0.04	1.47 ^c ± 0.02

TTA – titratable acidity; h – hour. Means with no common letters within a row are significantly different at ($p \leq 0.05$).

Table 2: Organic acids of sourdoughs from sorghum at different fermentation times.

Parameters (mg/kg)	0 h	24 h	48 h	72 h
Oxalic acid	138.39 ^a ± 0.16	233.30 ^b ± 13.31	278.36 ^c ± 0.56	394.90 ^d ± 1.59
Formic acid	0.64 ^a ± 0.01	4.34 ^b ± 0.02	5.32 ^c ± 0.09	7.08 ^d ± 0.03
L-Ascorbic acid	0.00 ^a	0.00 ^a	10.21 ^b ± 0.20	15.01 ^c ± 0.21
Lactic acid	0.00 ^a	2.90 ^b ± 0.03	0.00 ^a	0.00 ^a
Maleic acid	10.56 ^a ± 0.17	88.43 ^b ± 0.68	92.15 ^c ± 0.72	101.46 ^d ± 0.24
Shikimic acid	4.55 ^b ± 0.16	3.81 ^a ± 0.04	4.39 ^b ± 0.24	4.75 ^b ± 0.04
Succinic acid	0.00 ^a	5.27 ^b ± 0.01	6.38 ^c ± 0.17	6.58 ^c ± 0

h – hour. TTA – titratable acidity; h – hour. Means with no common letters within a row are significantly different at ($p \leq 0.05$).

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CHANGES IN LEVELS OF PHENOLIC COMPOUNDS DURING SORGHUM FERMENTATION

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Abstract

This study investigated the modifications of phenolic compounds during the fermentation of sorghum at different times (24, 48 and 72 h). The pH, titratable acidity (TTA) and phenolic compounds (luteolin, ferulic acid, taxifolin, apigenin, p-coumaric acid, sinapic acid, caffeic acid, gallic acid, vanillic acid) were determined at the different fermentation periods. Fermentation was observed to significantly increase ($p \leq 0.05$) the pH and the TTA of the samples, though a slight decrease was subsequently recorded after 72 h. Fermentation also resulted in both increases and decreases in the phenolic compounds, with groups of flavonoids and phenolic acids, not following a particular trend. Ferulic, gallic and sinapic acids were observed to have initially increased, followed by a subsequent decrease. Likewise, the two identified flavonoids in this study, which reduced after fermentation. Mechanisms of modification in the phenolic compounds could be related to release of phenolic compounds during fermentation, possible synthesis of phenolic compounds, hydrolysis of some phenolic-related compounds through enzymatic activities which improved extractability as well as metabolism of phenolic compounds by fermenting microorganisms. Findings from this study suggest that modification of phenolic compounds is compound specific and influenced by fermentation time.

Keywords: Cereal, Health promoting; Phenolic acids; Flavonoids; Fermented foods.

Introduction

Sorghum remains a vital crop and ranks fifth after wheat, maize, rice and barley, relative to its importance. It is one of the primary sources of calories to inhabitants of developing countries and a staple food for people residing in semiarid and arid regions of the world (Girard and Awika, 2018). Sorghum grains contain starch, lipids, minerals, vitamins as well as bioactive constituents. Of particular interest among the bioactive compounds in sorghum are the phenolic compounds, known to confer numerous health benefits. These phenolic compounds

exert several biological activities that are beneficial against cardiovascular diseases, hypertension, diabetes, obesity, cancer and dyslipidaemia (de Morais Cardoso et al., 2017).

Fermentation is one of the oldest means of processing sorghum into food forms and significant due to beneficial functionalities it confers on foods (Adebo, 2020). The process involves an intentional conversion/modification of a substrate into new products/forms, through microbial actions and subsequent fermented products are unique and of immense cultural values. Fermentation as a process could have different effects on cereal fermentation, possibly leading to increases, decreases as well as synthesis of other related phenolic compounds. Bali et al. (2020) studied the effect of fermentation time (72 h) on the phenolic compounds of millet. The authors found that fermentation increased the cinnamic acids and flavonoids contents by almost 30% while vitexin and vitexin 2"-O-rhamnoside contents were significantly higher in the fermented millet than raw millet flour. Furthermore, the phenolic extract from fermented millet flour exhibited antioxidant protection on human erythrocytes by *ex vivo* cellular antioxidant activity in red blood cells (Balliet. al., 2020). To the best of our knowledge, there is limited information on the impact of fermentation time on the phenolic compounds of sorghum. Hence, this study investigated the effect of fermentation time on the phenolic compounds (flavonoids and phenolic acids) of sorghum.

2.0 Materials and Methods

2.1 Materials

Light brown colored sorghum grains (*Sorghumbicolour*) were purchased from King Korn Pty (Ltd), Johannesburg, South Africa. Except otherwise specified, all reagents used for the study are of analytical grade.

2.2 Sample preparation

The sorghum grains were milled using a Perten Laboratory Mill 3310 (Perten Instruments AB, Helsinki, Finland) and passed through a 1 mm aperture size sieve (Analysette 3 Spartan, Fritsch, Germany) to obtain the flour.

2.3 Fermentation

Sterile distilled water was added to sorghum flour (1:1, v/w) and the mixture was then fermented at 37 °C for 24, 48, 72h in an incubator (Incoterm, Labotec, Johannesburg, South Africa). For each time, the fermentation process was done in triplicates and analyses (under-listed below were done).

2.4 pH, and titratable acidity (TTA)

A pH meter (pH 510, EutechPte Ltd, Singapore) was used to obtain the pH values of the samples. TTA was measured by mixing 90 mL of distilled water to 10 g of each sample. The mixture was allowed to rest, and the supernatant titrated with 0.1M NaOH (pH 8.3).

2.5 Extraction and quantification of phenolic compounds

Extraction and quantification of phenolic compounds was done using a modified method of Adebo et al. (2021). To 0.25 g of samples, 5 mL of acidified methanol (1% HCl in 80% aqueous methanol) was added, and the mixture was sonicated in an ultrasonic bath (AU 220, Argo Lab, Carpi, Italy) for 1 h. The mixture was then centrifuged (Eppendorf 5702R,

Merck, Germiston, South Africa) at $2100 \times g$ at $4\text{ }^{\circ}\text{C}$ for 10 min. The obtained supernatant was evaporated (Eppendorf Vacuum Concentrator Plus, Analytical Solutions, Johannesburg, South Africa) and the dried extract was reconstituted with 1 mL 50% liquid chromatographic grade methanol (Merck, Johannesburg, South Africa) and filtered into dark amber vials. Subsequent quantification was done on an ultra-high pressure liquid chromatography (UHPLC) system (Shimadzu, Kyoto, Japan) equipped with a DGU-403 degassing unit, LC-40B XR binary pumps, LC-40B XR solvent delivery module, SIL-40C XR auto-sampler, CTO-40C column oven as well as a SPD-M40 diode array detector. The extracts (2 μL) each were injected into the system and separation done on a Raptor C_{18} column ($2.7\text{ }\mu\text{m} \times 100\text{ mm} \times 2.1\text{ mm ID}$, Restek, Bellefonte, USA) at an oven temperature of $40\text{ }^{\circ}\text{C}$. Mobile phase A was 1% formic acid in Milli-Q water and B was 1% formic acid in a mixture of 50% methanol and acetonitrile and the total run time was 15 min.

2.6 Statistical analysis

All experiments and analyses were done in triplicates. Subsequent values were analysed with one way analysis of variance (ANOVA) (SPSS 22, IBM, New York, USA). Mean values and standard deviation were represented and values were compared using Tukey's test at $P \leq 0.05$ level of significance. Multivariate data analysis with principal component analysis was done on SIMCA 16 software (Umetrics, Umea, Sweden).

3.0 Results and Discussion

3.1 pH and TTA

Raw sorghum had a significantly ($P \leq 0.05$) higher pH) compared with the fermented samples (Table 1). The first phase of fermentation (0 to 24 h) of fermentation was characterized by a decrease in pH values from 6.57 to 3.53 and an increase in TTA from 0.43 to 1.35. In the second phase (between 24 and 48 h), both pH and TTA values increased from 3.53 to 4.10 and 1.35 to 1.91, respectively. In contrast to the previous phase, the final phase in this study (48 to 72 h) was characterized by a decrease in both pH and TTA values from 4.10 to 3.50 and 1.91 to 1.41, respectively. These general trends of reduction in pH with concomitant increase in TTA is in agreement with available literature on natural fermentation of sorghum (Coulibaly et al., 2022) and could be attributed to activities of *Lactobacillus* spp that tend to dominate spontaneous fermentation of natural sorghum fermentation (Yousif and El-Tinay, 2001). Equally vital is the dissociation of organic polymers by fermenting microorganisms which led to accumulation of acids. The trend of increase in pH after 48 h of fermentation could be attributed to loss of dry matter, due to physiological activities of the fermenting microorganisms that kept utilizing available nutrients for growth and metabolism (Adbelhaleem et al., 2008). On the other hand, the observed decrease in TTA after 72 h could be associated with the hydrolysis of available acids for generation of vital aroma pre-cursors, needed for the associated aroma of such fermented food product (Bressani et al., 2020).

Table 1. Biochemical properties and phenolic compounds in sorghum as influenced by fermentation time

Fermentation time (h)	pH	TTA (g/kg)	Phenolic acids (µg/g)					Flavonoids (µg/g)	
			Caffeic acid (λ -323 nm)	Ferulic acid (λ - 322 nm)	Gallic acid (λ - 271 nm)	Sinapic acid (λ - 319 nm)	Vanillic acid (λ - 261 nm)	Luteolin (λ - 348 nm)	Taxifolin (λ - 290 nm)
0	6.57 ^d (0.02)	0.34 ^a (0.01)	ND	22.65 ^a (0.45)	3.56 ^b (0.08)	ND	24.91 ^a (0.21)	3.32 ^a (0.02)	4.10 ^a (0.32)
24	3.53 ^{ab} (0.01)	1.35 ^b (0.03)	ND	ND	5.84 ^c (0.10)	ND	35.00 ^b (0.91)	4.21 ^{ab} (0.29)	5.86 ^b (0.38)
48	4.10 ^c (0)	1.91 ^d (0.04)	6.09 ^a (0.55)	ND	8.29 ^d (0.10)	2.15 ^a (0.25)	45.23 ^c (0.23)	5.03 ^{bc} (0.34)	7.43 ^c (0.08)
72	3.50 ^a (0.01)	1.47 ^{bc} (0.02)	ND	ND	1.68 ^a (0.08)	ND	ND	5.72 ^c (1.02)	ND

λ – wavelength; h– hours; ND – not detected; nm – nanometer; TTA – titratable acidity. Means with different superscripts under the same column are significantly different ($P \leq 0.05$). Values in brackets are the standard deviation of the respective means.

3.2 Phenolic compounds

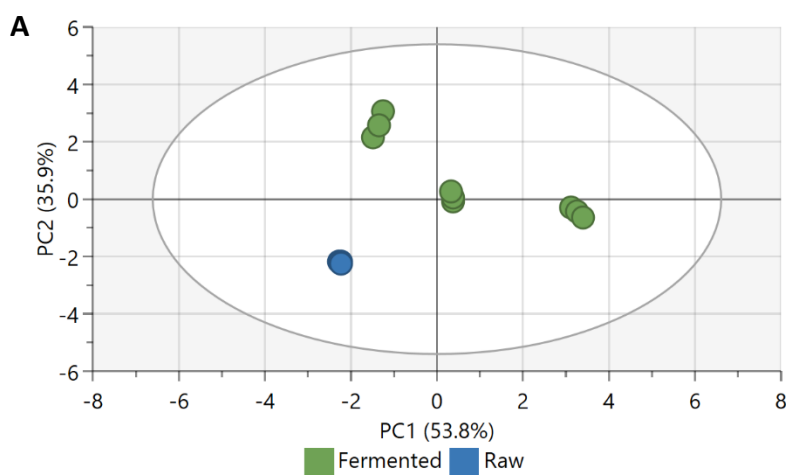
Of the five flavonoids (apigenin, kaempferol, luteolin, quercetin, and taxifolin) and six phenolic acids (caffeic, gallic, ferulic, p-coumaric, sinapic, and vanillic acids) investigated in this study, only two flavonoids (luteolin and taxifolin) as well as five phenolic acids (caffeic, ferulic, gallic, sinapic and vanillic acids), were quantified in the raw and subsequently fermented samples. Vanillic acid (λ – 261 nm) and ferulic acid (λ -322 nm) were the most abundant phenolic acid and flavonoid in the raw sorghum samples (Table 1). Caffeic acid and sinapic acid were initially not detected in the raw samples, but were only observed after 48 h of fermentation, after which it was not detected in the 72 h fermented sample. On the other hand, ferulic acid was detected in the raw samples, but was observed to decrease to levels which were not detected in subsequently derived fermented samples. On the contrary, gallic and vanillic acids were observed to initially increase with fermentation time, they both significantly ($P \leq 0.05$) reduced, after 72 h to 1.68 µg/g (for gallic acid) and not detected (for vanillic acid). Taxifolin (a flavonoid) was noted to have followed a similar trend of decrease observed for vanillic acid. Such trend observed for the phenolic compounds is somewhat similar to those of the pH and TTA values of an initial increase/decrease, especially in the 72 h fermented sample. Luteolin which is a flavonoid, was observed to have been the only phenolic compound to have increased consistently and significantly ($P \leq 0.05$) throughout the fermentation process.

Several mechanisms have been postulated for modification of phenolic compounds during cereal fermentation (Taylor and Duodu, 2015; Adebo and Medina-Meza, 2020), all of which have alluded to the fact that (i) phenolic compounds would most likely be modified during fermentation and (ii) there could be increases, decreases of phenolic compounds during

fermentation, as well as possible synthesis of phenolic compounds. Observed increases in the phenolic compounds reported here in could be attributed to their release from other macromolecules which were initially bound to these compounds. Likewise, could be the hydrolysis of some phenolic compounds through activities of microbially secreted enzymes which improved the extractability of the phenolic compounds. Decreases on the other hand could be ascribed to metabolism of phenolic compounds by fermenting microorganisms which were particularly more pronounced at longer fermentation time (72 h). Such modification should however not always be associated with bioactivity, as these reductions in some of the phenolic compounds might have led to the synthesis of other phenolic compounds with higher bioactivities.

3.3 Principal component analysis

Using an unsupervised multivariate data analysis technique (PCA), which assisted to reduce the dimensionality of obtained data in this study (pH, TTA and phenolic compounds), allowing the possibility of viewing the obtained dataset in groupings and clusters. The first two principal components (PCs) contributed 89.7% to the explained variation (Figure 1), which is good, as the two PCs explaining over 60% variation are generally acknowledged as being robust. PC1 contributed 53.8%, while PC2 contributed 35.9% of the explained variation. Figure 1A clearly shows a separation of the fermented samples (in green clusters), distinct from the raw/unfermented sample (in blue). Figure 1B on the other hand further shows distinct clusters of the investigated samples clearly showing that these samples are significantly distinct in correlation with data presented on Table 1.



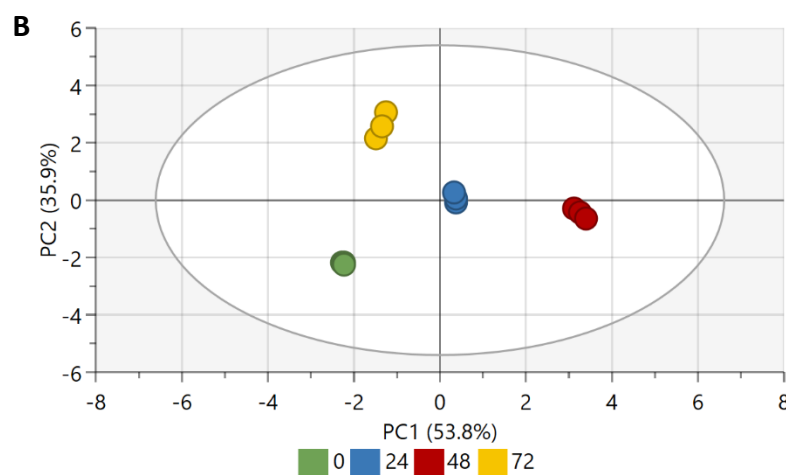


Figure 1.PCA plots showing (A) Relationship of unfermented and fermented samples, (B) relationship of samples fermented at different times

4.0 Conclusion

Fermentation thus clearly affects the composition of phenolic compounds in sorghum, with fermentation time playing a significant role. This could either be a possible decrease in levels or an increase. Answering the question of what these phenolic compounds have been bio-modified to would however require an untargeted profiling of all the phenolic compounds to identify possible bio-transformed monomers. Related to subsequent bioactivities will also be the need for other analyses related to such, especially different antioxidant activity techniques required to understand the influence of the fermentation periods on health promoting properties of the samples.

5.0 Acknowledgment

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PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF BLENDS OF PRE-TREATED RICE GRITS, DEFATTED GROUNDNUT FLOUR AND DATE PALM FLOUR

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The proximate and functional properties of different blends of pre-treated rice grits, defatted groundnut flour and date palm flour were investigated. Ground nut and date palm were processed to flour. Rice paddy was pre-treated using three treatments: fermentation, malt-ing and pre-gelatinization. These were followed by de-husking and milling into flour. The resulting grits were mixed together in the following ratios; 70:20:10, 60:30:10 and 50:40:10 of rice, defatted groundnut and date palm respectively while locally produced *kununshinkafa* flour from blend of untreated rice and groundnut was used as a control. The results obtained showed a significantly ($p < 0.05$) variations across the blends. The crude protein, fiber and ash content of the fermented rice was higher compared to other treatment while the fat and moisture content was low. Also, the water absorption capacity was high in the fermented rice. However, FD2 (Fermented rice and defatted groundnut and date palm 60:30:10) had better functional properties.

Keywords: Proximate properties, Functional properties, Instant *kununshinkafa* mix, Groundnut flour, Date palm flour

Introduction

Kunu is the generic name for all kinds of non-alcoholic beverages that are cereal based with specifications usually attached to denote the base cereal grain (Nahemiah *et al.*, 2014). There are various types of *kunu* that are processed and consumed in Nigeria. These include *kununzaki*, *kunungyada*, *kununshinkafa*, *kununtsamiya*, *kunun baule*, *kununjiko*, *kununakamu* and *kunungzakimba*. *Kununshinkafa* is a non-alcoholic beverage made from rice grits and groundnut with added spices to improve its flavour and taste. It is traditionally produced by roasting the ground nut, removing the skin, wet milling, sieving, boiling, addition of broken rice and continued cooking until a thick paste is achieved. *Kununshinkafa* is served at home and in public gathering as a refreshing drink and appetizer. They are also important weaning foods and are used extensively during Muslim fasting period of Ramadan. Some tribes in northern part of Nigeria (Hausa, Kilba, Marghi, Kajis and others) usually add groundnut paste or tiger nut milk to improve the nutritive value of the porridge. Spices are added to improve variety and flavours of the product, thus promoting appetite and aiding consumption. The spices are usually added in small quantities, though not to contribute to the nutritional quality of the food but to add to taste

and preserve the food as it contains phenolic compounds. Where ground nut paste is added, it substantially increases protein content. (Musa *et al.*, 2016). *Kununshinkafa* is cheap and nutritious when compared to carbonated drinks because it contains all the essential nutrients such as carbohydrates, fat, protein, minerals and vitamins (Ugwuanyi *et al.*, 2015). The inclusion of groundnut in the mix will make *kununshinkafa* to be an energy dense food because of their oil, and they are rich in vitamins and minerals (Eke-Ejiofor *et al.*, 2012). Foods containing roasted groundnuts have high consumer acceptance because of their unique roasted groundnut flavour. The aim of this study was to determine the proximate composition and functional properties of instant *kununshinkafa* mix from blends of pre-treated rice grits, defatted groundnut flour and date palm flour.

Materials and Methods

Rice paddy, ground nut and date palm were purchased from Kure Ultra-Modern Market Minna, Niger State Nigeria.

Rice paddy and groundnut were cleaned to remove stones, damaged grains and other extraneous materials. This was achieved through winnowing, sieving and hand picking. Rice paddy were fermented and malted as described by Ocheme *et al.* (2007) while pre-gelatinization was done as described by Bagirei *et al.* (2020). Defatted groundnut flour was prepared as described by Ocheme *et al.* (2018) with little modification. The nuts were sorted to remove extraneous materials and pretreated for 5 minutes with a mixture of 5.25% sodium hypochlorite and de-ionized water (1:10 v/v) to control microbial growth. The nuts were then be rinsed with de-ionized water (1:3 w/v) and oven dried at 50°C for 24h. The nuts were roasted at 140°C for 6min, de-coated manually and milled in a laboratory blender.

Date palm fruits were sorted, cleaned, washed, deseeded and oven dried at 50°C for 8h. The rice grits, defatted groundnut flour and date palm flour were blended in varying ratios. Rice and ground nut ratio were varied between 60%-90% with rice having 60% or more as the major ingredient. All the treated samples were blended as follows; 70:20:10, 60:30:10 and 50:40:10 for rice grits to, defatted groundnut flour and date palm fruits flour respectively. Proximate properties were determined according to (AOAC, 2005) while Functional properties was determined according to the method described by Alimi *et al.* (2016). Data collected was subjected to analysis of variance using SPSS version 20.0 statistical package.

Results and Discussion

The proximate composition of the blends is outlined in Table 1. The results show that the varying ratios of the mix significantly ($P < 0.05$) affected all the parameters. Majority of the blends containing fermented rice had higher protein, crude fibre and ash but lower fat and moisture contents. This suggests that fermentation had a more beneficial effect than the other treatments in this regard. Additionally, samples with fermented and malted rice had higher carbohydrates than samples with pre-gelatinized rice. From the results obtained in Table 2, the

water absorption capacity (WAC) was significantly higher ($P < 0.05$) across the blends. Water absorption capacity is the measure of the water sucked up and held. Blend FD1 and FD3 had the highest WAC which could be attributed to the higher ratio of rice in the blend in comparison to other blend samples which is similar to a report by Chandra *et al.*, (2015). WAC is essential in bulking and consistency of product. Oil absorption capacity ranged from 0.20 to 0.86, there was significant difference ($P < 0.05$) across the blends. OAC is an indication of the rate at which the protein binds to fat in food formulations. Flour's oil absorption ability is essential as it enhances mouth sensation and retains flavour (Bello and Ekeh, 2014). The Foaming capacity varied from 1.78 to 6.48% which was significantly higher ($P < 0.05$) across the blends respectively than other blends. Both emulsion capacity (EC) and emulsion stability (ES) shows no notable difference ($P < 0.05$) across the blends. Bulk density of the formulated blend varied from 0.57 to 0.97%. Blend CT had the least bulk density. Diet of lower density is required to allow swallowing with ease without choking or suffocation (Ikujenlola *et al.*,

2013). Lower density also enhances more intake or consumption of the food material thereby delivering more nutrients to the consumer.

KEYS

CT= Control (Traditional method) untreated rice and ground nut 50:50

FD1= Fermented rice and defatted groundnut and date palm 70:20:10

MD1= Malted rice and defatted groundnut 70:20:10

Table 2.0: Functional properties of the blends

PARAMETERS	Water absorption capacity	Oil absorption capacity	Foam capacity	Emulsion capacity	Emulsion stability	Bulk density
CT	0.80 ± 0.01 ^a	0.57 ± 0.02 ^a	2.78 ± 0.01 ^f	50.60 ± 0.02 ^a	43.58 ± 0.02 ^a	0.57 ± 0.01 ^a
FD1	1.00 ± 0.00 ^{ab}	0.85 ± 0.00 ^a	5.45 ± 0.10 ^d	47.94 ± 0.06 ^f	40.41 ± 0.02 ^a	0.72 ± 0.00 ^{abc}
MD1	0.96 ± 0.01 ^a	0.46 ± 0.02 ^b	1.78 ± 0.01 ^a	59.14 ± 0.15 ^b	43.55 ± 0.02 ^a	0.74 ± 0.01 ^{ab}
PD1	0.63 ± 0.01 ^f	0.48 ± 0.02 ^b	9.80 ± 0.02 ^a	58.85 ± 0.04 ^b	46.04 ± 0.04 ^a	0.68 ± 0.02 ^{cd}
FD2	0.99 ± 0.10 ^{bc}	0.80 ± 0.04 ^a	2.80 ± 0.10 ^f	47.85 ± 0.03 ^f	41.42 ± 0.03 ^d	0.69 ± 0.02 ^{cd}
MD2	0.79 ± 0.01 ^a	0.54 ± 0.02 ^b	4.69 ± 0.02 ^a	62.27 ± 0.28 ^a	46.55 ± 0.46 ^a	0.66 ± 0.10 ^d
PD2	0.76 ± 0.02 ^a	0.42 ± 0.02 ^b	6.77 ± 0.02 ^b	55.13 ± 0.08 ^d	40.64 ± 0.14 ^a	0.65 ± 0.03 ^d
FD3	1.04 ± 0.02 ^a	0.86 ± 0.02 ^a	6.57 ± 0.03 ^c	47.83 ± 0.02 ^f	41.61 ± 0.06 ^d	0.73 ± 0.02 ^{abc}
MD3	0.78 ± 0.00 ^a	0.57 ± 0.02 ^b	9.80 ± 0.04 ^a	47.92 ± 0.06 ^f	41.75 ± 0.25 ^d	0.75 ± 0.02 ^{bcd}
PD3	0.88 ± 0.02 ^d	0.20 ± 0.20 ^c	6.48 ± 0.03 ^c	57.72 ± 0.07 ^c	44.34 ± 0.11 ^b	0.79 ± 0.01 ^a

Values are means ± standard deviation of triplicate determination. Values in the same column with different superscripts are significantly different (p ≤ 0.05).

Table 1.0: Proximate analysis of the blends

PARAMETERS	Moisture content	Crude fiber	Crude protein	Ash	Fats	Carbohydrate
CT	8.21 ± 0.90 ^d	1.00 ± 0.00 ^d	15.55 ± 0.23 ^a	1.03 ± 0.05 ^a	2.00 ± 0.00 ^f	72.22 ± 0.10 ^a
FD1	10.18 ± 0.70 ^e	1.27 ± 0.02 ^c	15.66 ± 0.00 ^{bc}	2.95 ± 0.05 ^a	1.29 ± 0.06 ^a	68.20 ± 0.59 ^{bc}
MD1	10.22 ± 0.01 ^e	0.95 ± 0.02 ^d	12.45 ± 0.15 ^a	1.05 ± 0.02 ^a	3.83 ± 0.16 ^d	71.23 ± 0.57 ^a
PD1	11.55 ± 0.36 ^a	0.99 ± 0.02 ^d	16.17 ± 0.05 ^a	1.42 ± 0.08 ^d	5.00 ± 0.00 ^c	64.88 ± 0.46 ^d
FD2	10.15 ± 0.13 ^c	2.15 ± 0.05 ^a	16.03 ± 0.03 ^{ab}	2.83 ± 0.16 ^{ab}	1.62 ± 0.03 ^a	67.17 ± 0.04 ^c
MD2	10.26 ± 0.05 ^{abc}	1.01 ± 0.01 ^d	12.65 ± 0.20 ^a	2.60 ± 0.1 ^b	4.75 ± 0.25 ^c	68.67 ± 0.60 ^{bc}
PD2	10.82 ± 0.59 ^{bc}	0.94 ± 0.04 ^d	13.25 ± 0.95 ^f	1.98 ± 0.02 ^c	9.45 ± 0.48 ^b	63.24 ± 1.29 ^{de}
FD3	10.36 ± 0.09 ^{bc}	0.99 ± 0.00 ^d	14.60 ± 0.70 ^d	1.48 ± 0.03 ^d	4.00 ± 0.00 ^d	68.34 ± 0.09 ^{bc}
MD3	10.36 ± 0.06 ^{bc}	1.01 ± 0.01 ^d	14.45 ± 0.11 ^d	1.51 ± 0.06 ^d	2.99 ± 0.05 ^e	69.31 ± 0.45 ^b
PD3	10.99 ± 0.06 ^{ab}	2.00 ± 0.00 ^b	13.82 ± 0.07 ^e	1.48 ± 0.03 ^d	10.09 ± 0.07 ^a	61.56 ± 0.05 ^e

Values are means ± standard deviation of triplicate determination. Values in the same column with different superscripts are significantly different (p ≤ 0.05).

PD1=pre-gelatinized rice and defatted groundnut 70:20:10

FD2=Fermented rice and defatted groundnut and date palm 60:30:10

MD2=Malted Rice, defatted ground nut date palm fruits 60:20:10

PD2=pre-gelatinized rice and defatted groundnut 60:30:10

FD3= Fermented rice and defatted groundnut and date palm 50:40:10

MD3= Malted Rice, defatted ground nut date palm fruits 50:40:10

PD3=pre-gelatinized rice and defatted groundnut 50:40:10

Conclusion: Though CT, (Control Traditional method) has the least bulk density. Fermented rice blends has the best quality parameters. However, FD2 (Fermented rice and defatted groundnut and date palm 60:30:10) had better proximate and functional properties. Thus, increased therapeutic potentialities.

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EVALUATION OF BREAKFAST MEAL FROM THE BLENDS OF AFRICAN YAM BEANS, FIRM RIPE PLANTAIN AND SESAME FLOUR

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ABSTRACT

Evaluation of breakfast meal from the blends of sesame, African yam beans and firm ripe plantain was carried out. The proximate values showed, moisture content 6.41-6.47%, ash 2.05-2.21%, fat 1.87-2.34%, fibre 0.65-0.88%, protein 6.65-11.90% and carbohydrate 76.26-82.37%. The functional properties had the values as bulk density 0.46-0.512g/ml, foam capacity 6.67-36.67%, viscosity 138.07-184.94cp, WAC 2.00-3.30g/g, OAC 0.20-1.80g/g. The sensory attributes showed that the general acceptability was highest for the sample AOE at $P < 0.05$, this was due to the reduction of African yam beans and increase in firm ripe plantain and sesame flour. It was discovered that as the African yam beans decreases the acceptability increased. The composite flour for the breakfast meal production is therefore recommended due to its nutritive value.

Keywords

INTRODUCTION

The Word “breakfast” is a compound of “break” and “fast” which literally means “breaking the fast” from the last meal or snack from the previous day. Breakfast is the nutritional foundation or the first meal of the day (Kowtaluk, 2001). Nutritional experts have referred to breakfast as the most important meal of the day, citing studies that found people who skip breakfast to be disproportionately likely to have problems with concentration, metabolism and weight (Mayo Clinic, 2009). Breakfast meals vary widely in different cultures around the world. It often includes a carbohydrate source such as Cereals, fruit and or vegetable, protein sometimes dairy, and beverage.

In developing countries, particularly sub-Saharan Africa, breakfast meals for both adults and infants are based on local staple diet made from cereal, legumes, cassava and potatoes tubers. However, the most widely eaten breakfast foods are cereal (Kent, 1983). It has been proposed that malnutrition in developing countries can be combated using mixture of tubers, cereals and legumes in the countries.

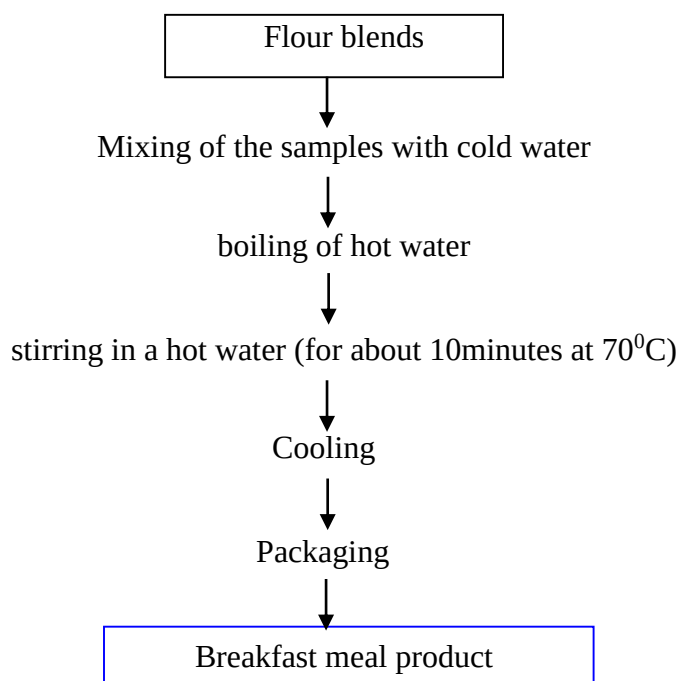
Breakfast meal is regarded by many dieticians as the most important meal of the day because food consumed at breakfast seems to be more utilized than the same amount eaten at night. Most researchers who have studied the effect of eaten breakfast has suggested that the benefits are due mainly to the protein that is eaten from the meal because high protein breakfast were found to be better than low protein breakfast in helping to maintain a normal blood sugar levels between mid-morning and lunch. (Ensiminger, 1994).

Breakfast is basically produced from cereals are by far the important plant eaten by man. Cereals are typically a low fat, nutrient dense food with many essential vitamins and minerals, such as zinc, phosphorus, calcium and essential vitamins such as iron, B-vitamins, and zinc. Cereals also provide the important benefits of grains and are good for breakfast meal. (Abdullah, 1995).

PRODUCTION OF BREAKFAST CEREAL

The recipe for the breakfast cereal production as determined by Uche Ukah (2004) was used. The flour blends was used as the basis with other ingredients as shown below.

Flour blends	100%
Water	varying
Sugar	20%



(Source: Adedeye and Adewoke, 1992)

PROCESSING METHOD FOR THE BREAKFAST

The processing method used for the production of the breakfast cereal production as the straight dough baking method as described by Kent (1995). The dried ingredients were weighed using cylinder. The flour sample were supplemented and enriched with a different proportion of African yam bean flour, firm ripe plantain flour and mature sesame flour as follows respectively (100%) (80%, 15%, 5%), (70%, 20%, 10%,) (60%, 25%, 15%), (50%, 30%, 20%). The sugar 20%, salt 2%, baking powder 2%, whole milk powder, 1 small teaspoon each and water variable amount were weighed out.

All the appropriate amount of ingredients were put in the mixture bowl and homogeneously mixed into smooth dough. Few drops of the Vanilla were added to enhance the sweet aroma of the product. The dough was kneaded manually, the dough was divided into smaller unit and a varying brown colour was obtained. The baked product was tingly sliced manually into uniform thickness and dried in the oven at 50⁰c for 45⁰c for 1 hour to obtain a constant weight. The dried product was grind with a manual attrition mill to desired particle size, was sieved and stored in a clean dried air tight container.

SAMPLE	AFRICAN YAM BEAN FLOUR (%)	FIRM RIPE PLAN-TAIN FLOUR (%)	SESAME FLOUR (%)
AOA	100	0	0
AOB	80	15	5
AOC	70	20	10
AOD	60	25	15
AOE	50	30	20

METHOD

The proximate compositions were determined using the standard methods as described by AOAC, 2006, while carbohydrate content was determined by difference as described by Onwuka, 2005. Functional properties were also determined using the standard methods described by Onwuka, 2005.

RESULTS AND DISCUSSION

Table 1. Proximate, functional and Sensory of breakfast meal from the blends of african yam beans, firm ripe plantain and sesame flour

Parameters	AOA	AOB	AOC	AOD	AOE	LSD
Moisture(%)	6.41 ^a ±0.10	6.45 ^a ±0.10	6.47 ^a ±0.10	6.44 ^a ±0.30	6.41 ^a ±0.01	0.12
Ash (%)	2.05 ^c ±0.01	2.12 ^b ±0.01	2.13 ^b ±0.30	2.18 ^a ±0.03	2.21 ^a ±0.10	0.05
Fat (%)	1.87 ^d ±0.10	2.02 ^c ±0.01	2.20 ^b ±0.10	2.28 ^c ±0.01	2.34 ^a ±0.10	0.07
Fibre(%)	0.65 ^b ±0.01	0.70 ^{ab} ±0.01	0.75 ^{ab} ±0.01	0.85 ^a ±0.10	0.88 ^a ±0.10	0.20
Protein (%)	6.65 ^e ±0.10	9.10 ^d ±0.10	10.41 ^c ±0.10	11.29 ^b ±0.01	11.90 ^a ±0.01	0.60
CHO (%)	82.37 ^a ±0.01	79.61 ^b ±0.01	78.94 ^{bc} ±0.1	76.94 ^c ±0.10	76.26 ^c ±0.10	2.75
Bulk density (g\ml)	0.461 ^d ±0.10	0.487 ^c ±0.30	0.495 ^b ±0.10	0.501 ^b ±0.30	0.512 ^a ±0.01	0.01
Foam cap (%)	6.67 ^d ±0.10	14.44 ^d ±0.30	17.78 ^c ±0.30	25.57 ^b ±0.03	36.67 ^a ±0.03	11.00
Viscosity(cp)	138.07 ^e ±0.00	146.39 ^a ±0.00	157.08 ^c ±0.00	168.52 ^b ±0.00	180.94 ^a ±0.00	12.30
WAC (g/g)	3.30 ^a ±0.10	3.10 ^{ab} ±0.30	3.00 ^b ±0.07	2.10 ^c ±0.37	2.00 ^c ±0.05	0.28
OAC (g/g)	0.20 ^c ±0.01	0.40 ^b ±0.10	1.40 ^b ±0.10	1.50 ^b ±0.10	1.80 ^a ±0.01	0.25
Colour	6.90	7.00	7.10	6.70	6.70	0.48
Taste	5.10	5.60	5.00	8.30	6.00	0.48
Aroma	4.10	5.30	4.90	6.70	5.40	0.92
General Acceptability	5.20	5.90	5.60	8.80	5.60	0.46

AOA – 100% AYB, AOB – 80% AYB 15% firm ripe plantain and 5% sesame flour, AOC - 70% AYB, 20% FRP, 10% sesame flour, AOD – 60% AYB, 25% FRP, 15% sesame flour, AOE – 50% AYB, 30% FRP, and 20% sesame flour

DISCUSSION

The proximate composition of breakfast meal produced from African yam bean, firm ripe plantain and sesame seed. The moisture content ranged from 6.41±0.010 to 6.47±0.01% with the highest value observed in the breakfast meal containing 50.30:20 formulations. This is probably due to the high moisture content of sesame that has the ability to imbibe moisture from the environment. The low moisture content generally observed in the samples may add the advantage of prolonging the shelf life of the product if properly packaged.

The results of the ash content of the formulated sample showed significant differences ($P < 0.05$) with values ranging from 2.05 ± 0.01 to $2.21 \pm 0.10\%$. But this was not in conformity with the report obtained by (Agunbiade and Ojezele, 2010) and (Adedeye and Adewoke 1992). The high ash values recorded in this work maybe attributed to the presence of firm ripe plantain and sesame as part of the ingredients in this study. The fat content of the formulated breakfast meal ranged from $1.87 \pm 0.10\%$ to $2.34 \pm 0.10\%$. This range of value obtained are seen to be of the same range with the control (weetabix) (2.00%). The value increased with the increase in the quantity of sesame percentage added. The low fat level maybe beneficial as it ensures longer shelf life and stability for the products as reported by Reebeet *al.* (2000) The crude fiber content of the formulated breakfast meal ranged from 0.65 ± 0.016 to $0.88 \pm 0.10\%$. However this is not in conformity with reports from (Agunbiade and Ojezele, 2010). The protein content of the samples ranged from $6.65 \pm 0.10\%$ to $11.90 \pm 0.01\%$. This however demonstrates the effect of supplementing legumes in breakfast cereals.

The carbohydrate value of the formulated samples ranged from 82.77 ± 0.01 to $76.20 \pm 0.10\%$. and this shows that it is nutritionally adequate from the analysis carried out.

The result of bulk density of the breakfast cereal ranged from 0.461 ± 0.01 to 76.20 ± 0.10 g/ml with the highest value found in the sample with 100% formulation. There was a gradual reduction of the bulk density with increase in the addition of sesame flour although the sample with 80.15:5 formulation did not have significant difference ($p > 0.05$). However Mbaeyi (2005) recorded values that were similar to those obtained in this study ($0.3341 - 0.7267$ g/ml).

The foam capacity of the sample ranged from 6.67 ± 0.10 to $36.67 \pm 0.01\%$ with the highest value observed in the sample with 100% formulation. There was a gradual decrease in foam capacity with increasing addition of sesame flour.

The results obtained from water absorbing capacity of the formulated breakfast cereals ranged from 3.30 ± 0.10 to $2.00 \pm 0.05\%$. It was found to increase with increase in firm ripe plantain flour inclusion. The oil absorption capacity of the breakfast meal ranged from 0.20 ± 0.01 to $1.80 \pm 0.01\%$ with the highest value recorded for the sample with 100% formulation.

The general acceptability of these products to the control (Weetabix) showed no much difference at $P < 0.05$ except Sample AOD.

CONCLUSION AND RECOMMENDATION

The study showed that acceptable ready to eat breakfast cereals could be produced from African yam bean and firm ripe plantain, sesame flour. Evaluation of the products showed values that compared favourably with the commercial control sample (weetabix) as they have been shown to be good sources of protein.

The study has shown that producing breakfast cereals with sesame seed and legumes could boost the protein level (up to 18%) in the final product. The process also influenced low moisture content (3-4%) of the product, which is important for transportation and extension of the shelf life, if properly packaged. Most of the formulated samples scored above average by sensory panelists and showed some similarities with weetabix (control), ($p < 0.05$), implying its potential acceptability when commercialized.

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PHYSIOCHEMICAL PROPERTIES OF BREAD PRODUCED FROM SOURSOP PEEL POWDER AND WHEAT COMPOSITE FLOUR

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ABSTRACT

Proximate composition of bread produced from wheat flour and soursop peel powder composite flour was investigated. Wheat flour and soursop peel powder were substituted in the ratio 100:0, 95:5, 90:10, 85:15, 80:20 and 75:25 coded as WRA, NMA, MAE, PSU, ALT and QSE respectively. Bread from 100% wheat flour (WRA) served as control. The Proximate composition of the bread samples were carried out. From the result, physiochemical properties revealed that moisture content ranged from (28.33-33.00%), protein (9.53-12.10%), fat (2.71-3.44%), fibre (1.03-1.31%), ash (1.83-3.50%) and carbohydrate (48.29-55.90%). Control sample (WRA) showed highest moisture content. There was increase in protein, fat and carbohydrate values with increase in soursop peel powder. However, crude fibre and ash did not follow a regular pattern. Sample QSE had increases in all the physiochemical properties except in moisture content. These finding showed that wheat flour could be substituted with soursop peel powder up to 5 – 25 % in bread production.

Key words: Soursop, Bread, Wheat, Physiochemical properties, Soursop peel powder.

Introduction

The soursop (*Annonamuricata* L.) generally called *Graviolaguanabana* (Adefeghaet *et al.*, 2015) is a green leafy plant which belong to *Annonaceae* family (Florence *et al.*, 2014). It is a fruit tree found mostly in the tropics and commonly cultivated in South America, Central America, Africa and Asia (Kossouohet *et al.*, 2007). Soursop peel has been proved to have a lot of nutrients and minerals which are very useful for the body. Some of them are acetogenins, annocatacin, annocatalin, annohexocin, annonacin, anomurian, annomurine, anonol, caclourine, gentisic acid, gigantertronin, linoleic acid, muricapentocin, niacin, phosphorus, calcium, carbohydrate, vitamin C, vitamin B₁, vitamin B₂, and many nutritional contents; then, the benefits of soursop peel is that they are very good for the health (Mardiana and Adeanne, 2015). Soursop peel also have antibacterial compounds such as steroids, saponins, tannins, and flavonoids (Badrie and Schauss, 2010).

Bread products are well accepted worldwide due to its nutritional content among cereal and cereal products. Generally, bread is rich with carbohydrate, protein, minerals (e.g. calcium and iron), and vitamins (e.g. B complex vitamins) (Dhingra and Hood, 2001). The main ingredients of bread products are high protein wheat flour, yeast or other leavening agent and salt. One of the medicinal plants is soursop which provides various health benefits obtained from the peel (Mardiana and Adeanne, 2015). This plant is reported very useful in preventing and treating cancer, treating hemorrhoid, reducing cholesterol, eliminating acne (Ministry of Health, 2018), fever, respiratory illness, liver, heart and kidney infection, anti-stress and wound healing (Naspiah *et al.*, 2013). Incorporating soursop peel powder in bread is expected to increase the medicinal value of bread from the pharmacological point of view and it will also improve the edibility of the peel. Hence, the objective of this study was to produce and evaluate the physiochemical properties of bread produced from soursop peel powder and wheat composite flour.

Materials and Methods

All the ingredients (refined wheat flour, sugar, butter, yeast and soursop fruit) for preparation of soursop (*Annonamuricata* L.) bread were purchased from a local market in Ikorodu, Lagos State. Drying of fresh soursop peel was carried out, with slight modifications, following the method reported by Ladele *et al.* (2014). Fresh, undamaged peel was sorted and washed with clean water thoroughly to remove all dirt. The water was then drained, air-dried peel was then dried in a tray drier at 50-70°C for 4 hours. The dried peel was milled, sieved (80 mesh size), packaged in zip lock bags and stored. The preparation flow chart is shown in Figure1. Bread was produced using the straight dough method as reported by Chauhan *et al.* (1992) with slight modification. All the ingredients were weighed; flour (200g), sugar (24g), fat (32g), yeast (6g) and water (170mL) and were thoroughly mixed manually for 40 min. The mixture was kneaded properly until the dough became elastic. The kneaded dough was transferred into greased (with margarine) baking pans and covered with aluminum foil. It was allowed to ferment for 55 min at room temperature. The fermented dough was allowed to undergo proofing at room temperature for 90 min. It was transferred to the oven for baking at 230°C for 30 min. The loaves were removed from the pans and allowed to cool before packaging in polyethylene bags. Proximate composition were determined using the method described by AOAC (2010).

Statistical analysis

All data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS), version 20.0 to test the level of significant difference at 5% level

of probability ($p < 0.05$). Duncan Multiple Range Test was used to separate the means where significant differences existed.

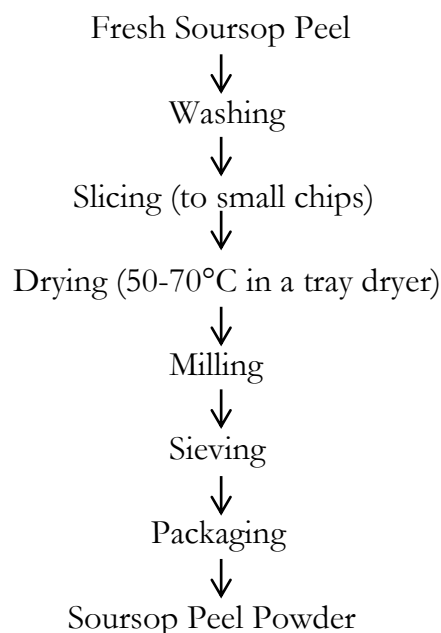


FIGURE 1: FLOWCHART FOR PRODUCTION OF SOURSOP PEEL FLOUR
SOURCE: LADELE *ET AL.* (2014) WITH MODIFICATION

Result and Discussion

Proximate composition of bread produced from soursop peel and wheat composite flour are shown in Table 1. Parameters determined include the moisture content, ash content, crude protein, fibre content, crude fat content and carbohydrates content. These analyses are important for determination of food quality and can be used for nutritional labeling. It also determines the storage ability and quality of flour and susceptibility to microbial contamination (Frazier and Westhoff, 2005). The higher moisture content above 14% attracts mold, bacteria, and insects all of which cause deterioration during storage. The moisture content of the bread ranged from 28.33-33.00%. The highest moisture content was observed in sample WRA while the lowest value was recorded in sample PSU. There was no significant difference ($p > 0.05$) among the samples except sample PSU. It was observed in this study that the moisture content decreased with increase in soursop flour inclusion though the decrease does not follow regular pattern. This trend is similar to the findings reported by Nwosu *et al.*, (2014); Olaoye and Onilude, (2008) who reported 31.04-31.46% and 30.98-33.84% for bread produced from substitution of wheat flour with cassava flour using soybean as an improver and baked products

from blends of wheat bread fruit flours respectively and slightly lower to the range 31.04-36.39% reported by Peluola-Adeyemi *et al.* (2021) for bread produced from wheat flour using avocado (*perseaamericana*) paste as substitute. However, it contrasts the studies reported by Njintang *et al.*, (2008) and Olaoye *et al.* (2006), who found out that, moisture content of the composite breads increased with increasing non-wheat flour substitution. The moisture content observed in this study are higher than 14% moisture content for dried products, the implication is that the shelf life of the composite bread will be more susceptible to microbial contamination. The higher the moisture content of food materials the lower the shelf stability (Aluge *et al.*, 2016). The protein content ranged from 9.53-12.10%. The highest value was observed in sample QSE while the lowest value was observed in sample PSU. There was significant difference ($p > 0.05$) among the samples except sample WRA and ALT. The result obtained for protein in this study was found to be higher in sample MAE, ALT and QSE compared to the control sample (WRA). The significant ($p < 0.05$) increase in the protein content of the composite breads with increasing levels of soursop flour inclusion could be attributed to the protein composition of these added materials. This confirms earlier reports by Emelike and Akusu (2019) that soursop has a high protein content of 15.62% as compared to other fruits. Zabidi and Yunus (2014) also added that soursop flour could be utilized in enhancing the protein content of various food products. This is contrary to the findings of Malomo *et al.*, (2011) who reported that the crude protein content decreased with increasing breadfruit and bread nut flour substitution. The fat content of the bread ranged from 2.71-3.44%. The highest value was observed in sample QSE while the lowest value was recorded in sample PSU. There was significant difference ($p < 0.05$) among the samples except sample WRA and ALT. It was observed in this study that the fat content of the bread samples increased with increase in soursop peel flour inclusion. The higher presence of fat in wheat bread, would help to increase the sources of fat soluble vitamins and precursors such as vitamin A and provitamin A carotenoid as well as the total energy content as reported by Khating *et al.* (2014). This study contrasts the work of Iombor and Banjo (2018) who observed a decrease in the fat content of bread substituted with soursop flour from 8.50 to 4.00% as substitution of soursop flour increased. Fat plays significant role in the shelf life of food product as fat have the ability of promoting rancidity in foods leading to development of unpleasant and odorous compounds (Barber *et al.*, 2017). The crude fiber content ranged from 1.03-1.31%. The highest value was recorded in sample QSE while the lowest content value was recorded in sample PSU. The increase in crude fiber of this study does not follow regular trends. The increase in some of the samples with soursop peel flour could be due to the high fibre content of soursop flour: (28.21%) as reported by Wijewardana *et al.*, (2016). Significant difference ($p > 0.05$) existed among the samples except sample WRA and QSE. The ash content ranged from 1.83-3.50%. The highest value was recorded in samples WRA and QSE while the lowest value was recorded in sample MAE and ALT. There was no Significant differences ($p < 0.05$) between samples WRA and QSE, NMA and PSU, MAE and ALT. Ash content is an indication of the mineral content of a food (Ndifeet *et al.*, 2013). The ash content reported in this study contrasts the ash content observed by some authors (Scheuer *et al.*, 2006; Nwosu *et al.*, 2014; Olaoye and Onilude, 2008; Das *et al.*, 2012) during the production of bread. The decrease in ash content of the bread samples could be attributed to level of ash content in the soursop. The value

reported in this study are concomitant with the range (1.09-2.99%) reported by Peluola-Adeyemi *et al.*, (2021) for bread produced from wheat flour using avocado (*perseaamericana*) paste as substitute. Ash values from this study was higher with range of values of (0.79 to 1.48% and 0.97 to 1.88%) for granola produced from different cereal grains (Eke-Ejiofor and Beleya, 2016) and granola formulated with puffed glutinous rice and selected dried sunnah foods (Agbaje *et al.*, 2016). The carbohydrates content ranged from 48.29-55.90%. The highest value was recorded in sample PSU while the lowest value was recorded in sample WRA. Significant difference ($p < 0.05$) existed among the samples except samples MAE and ALT. The values obtained are lower than the values (54.03-61.46% and 52.25-60.58%) reported by Scheuer *et al.* (2006) and Olaoye and Onilude (2008) respectively. The decrease in carbohydrate content of the bread samples could be attributed to low carbohydrate content in the soursop peel flour and reduction in the proportion of wheat flour. However, the variation observed in this study may be due to effect of different cultivars. Composite flour from soursop peel composite flour could be used to manage cases of protein energy malnutrition which is prevalent in most developing countries of the world (Akinola *et al.*, 2015)

TABLE 1: PROXIMATE COMPOSITION OF BREAD PRODUCED FROM WHEAT/SOURSOP PEEL COMPOSITE FLOUR

SAM- PLE	Moisture Content (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Crude Ash (%)	Carbohy- drates (%)
WRA	33.00±2.00 ^b	10.93±0.14 ^c	3.10±0.04 ^c	1.18±0.02 ^c	3.50±0.50 ^c	48.29±2.30 ^a
NMA	31.00±1.00 ^b	10.42±0.15 ^b	2.96±0.04 ^b	1.13±0.02 ^b	2.83±0.29 ^b	51.66±1.12 ^b
MAE	31.00±1.00 ^b	11.59±0.03 ^d	3.29±0.01 ^d	1.25±0.00 ^d	1.83±0.29 ^a	51.03±1.07 ^{ab}
PSU	28.33±1.76 ^a	9.53±0.17 ^a	2.71±0.05 ^a	1.03±0.02 ^a	2.50±0.00 ^b	55.90±1.75 ^c
ALT	32.00±0.87 ^b	11.07±0.03 ^c	3.14±0.01 ^c	1.20±0.00 ^c	1.83±0.29 ^a	50.76±1.05 ^{ab}
QSE	31.00±1.32 ^b	12.10±4.87 ^e	3.44±0.01 ^e	1.31±0.00 ^e	3.50±0.50 ^c	48.65±1.30 ^b

*Mean± standard deviation with same superscripts along the column are not significantly different at ($p > 0.05$)

KEY: Sample WRA: 100% wheat flour; Sample NMA: 95% wheat flour and 5% soursop peel flour; Sample MAE: 90% wheat flour and 10% soursop peel flour; Sample PSU: 85% wheat flour and 15% soursop peel flour; Sample ALT: 80% wheat flour and 20% soursop peel flour; Sample QSE: 75% wheat flour and 25% soursop peel flour

Conclusion

Partial or total substitution of wheat flour with flour of other cereals, legume or oil seeds and peels can serve as a means of diversifying and upgrading local agricultural food products which will therefore result to reduction in level of waste generated from agricultural products. From the results of the proximate, it was observed that the use of soursop peel flour in bread production produced bread product of high nutritional value. The inclusion of soursop peel flour up to 15% could give a confectionary product of high quality that is comparable with 100%

wheat flour. This work recommends the use of soursop residues to produce flour to make bread using soursop peel flour substitution level, giving a use to the wastes generated.

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FUNCTIONAL PROPERTIES OF FLOUR PRODUCED FROM SOURSOP PEEL AND WHEAT COMPOSITE FLOURS

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ABSTRACT

Functional properties of flour produced from wheat and soursop peel composite flour was investigated. Wheat flour and soursop peel powder were substituted in the ratio 100:0, 95:5, 90:10, 85:15, 80:20 and 75:25 coded as WRA, NMA, MAE, PSU, ALT and QSE respectively. Bread from 100% wheat flour (WRA) served as control. The functional properties of the flour samples were carried out. From the result, the functional properties of the bread revealed that oil absorption capacity ranged from 75.00-83.67%, water absorption capacity (63.33-80.67%), swelling capacity (6.41-7.23%), solubility index (12.67-17.67%) and bulk density (0.75-0.87 ml/g). The control showed lower functional properties with exception in solubility index and swelling capacity.

Introduction

The Soursop (*Annonamuricata* L.) generally called Graviola, guanabana (Adefegha *et al.*, 2015) is a green leafy plant which belong to *Annonaceae* family (Florence *et al.*, 2014). It is a fruit tree found mostly in the tropics and commonly cultivated in South America, Central America, Africa and Asia (Kossouh *et al.*, 2007). Soursop peel has been proved to have a lot of nutrients and minerals which are very useful for the body. Some of them are acetogenins, annocatacin, annocatalin, annohexocin, annonacin, anomurian, annomurine, anonol, cacourine, gentisic acid, gigantertronin, linoleic acid, muricapentocin, niacin, phosphorus, calcium, carbohydrate, Vitamin C, Vitamin B₁, Vitamin B₂, and many nutritional contents; then, the benefits of soursop peel is that they are very good for the health. Soursop peel also have antibacterial compounds such as steroids, saponins, tannins, and flavonoids (Badrie and Schauss, 2010). Zuwariah and Aziah (2009) substituted banana flour in wheat bread. Modifying banana and plantain flour could increase its utilization in the food industry particularly as an additive. It has been recorded that, modified flours can offer functional benefits to variety of foods and functional foods. The aim of this study was to characterize the functional properties of flour produced from soursop peel and wheat composite flour.

Materials and Methods

PRODUCTION OF SOURSOP PEEL FLOUR

Drying of fresh soursop peel was carried out, with slight modifications, following the method reported by Ladele *et al.* (2014). Fresh, undamaged peel was sorted and washed with clean water thoroughly to remove all dirt. The water is then drained and peels are air dried for some time. The washed and air-dried peel is then dried in a tray drier at 50-70°C for 4 hours. The dried peel was milled, sieved (80 mesh size), packaged in zip lock bags and stored. The preparation flow chart is shown in Figure 1.



FIGURE 1: FLOWCHART FOR PRODUCTION OF SOURSOP PEEL FLOUR

SOURCE: LADELE *ET AL.*, (2014) WITH MODIFICATION

DETERMINATION OF FUNCTIONAL PROPERTIES OF THE FLOUR SAMPLES

The bulk density was determined using the method of Noor (2015), Swelling capacity was determined by modification of the Lin and Zayas (1987) method. Water absorption was determined by the modified centrifuge method of Lin and Zayas (1987). Solubility index was determined using the method described by Takashi and Sieb (1988). All data obtained were analyzed in triplicate determinations. They were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS), version 20.0 to test the level of significant difference at 5% level of probability ($p < 0.05$). Duncan Multiple Range Test was used to separate the means where significant differences existed.

Result and Discussion

The functional properties of flour produced from soursop peel and wheat composite flour are shown in Table 1. The functional properties determine whether the blends would be useful in bakery products where hydration to improve handling desired and in ground meat, doughnuts, and pancakes where oil absorption property is of prime importance (Mepha and Tboh, 2007). The oil absorption capacity ranged from 75.00-83.67 %. The highest value was recorded in sample ALT while the lowest value was recorded in sample WRA. Oil absorption capacity has been attributed to the physical entrapment of oil. This is important since fat acts as flavour retainer and increases the mouth feel of food. It is an indication of the rate at which the protein binds to fat in food formulations. Oil absorption capability required in most food applications, such as in bakery products, wherein required in flavour retention and improvement of palatability (Abu *et al.*, 2005). There was no significant difference ($p>0.05$) among the samples. The result of this study is similar to the report of Ekunseitan *et al.*, (2016) who reported oil absorption capacity of 67.70 – 79.45 for wheat-mushroom-HQCF blends. The oil absorption capacity is the flavor retaining capacity of flour which is very important in food formulations (Odoemelam, 2005). The values obtained were higher than those reported by previous authors who worked on breadfruit flour; 0.50 ml/g to 1.25 ml/g (Appiah *et al.*, 2011), 2.8 ml/g (Odoemelam, 2005) and within the range 67.70 – 79.45 reported by Ekunseitan *et al.* (2016) for wheat-mushroom blends. Increase in oil absorption capacity may also be attributed to the presence of more hydrophobic proteins which showed superior binding of lipids (Ekunseitan *et al.*, 2016) and this could explain the reason why samples with soursop peel powder which is rich in protein had higher values of oil absorption capacity. The water absorption capacity of the flour ranged from 63.33-80.67%. The highest water absorption capacity was observed in sample ALT while the lowest value was recorded in sample WRA. There was no significant difference ($p>0.05$) among the samples. Water absorption capacity is referring to the ability of the *flour or starch to hold water against gravity that can comprise of bound water, hydrodynamic water, capillary water and physically entrapped water (Moure *et al.*, 2006). In this study, the water absorption capacity increased with increase in substitution level. The increase in the water absorption capacity of the composite flours might be attributed to the presence of hydrophobic amino acids which interferes with the ability of the wheat starch to absorb water (Kaur and Singh, 2005). This effect might also be due to the loose association of amylose and amylopectin in the native starch granules and the weak binding forces that maintains the starch granules structure (Sanni *et al.*, 2006). The swelling capacity ranged from 6.41-7.23(ml/g). The highest value was observed in sample WRA while the lowest value was observed in sample QSE. There was no significant difference ($p>0.05$) among the samples except sample WRA and QSE. It was reported by (Blessing, 2014) that the swelling capacity of flour granules is an indication of the extent of associative forces within the granule. The swelling capacity of the flour samples with soursop flour were slightly lower compared to the control sample. The variation in the swelling capacity indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water (Blessing, 2014). The solubility index

ranged from 12.67-17.67%. The highest value was recorded in sample WRA while the lowest value was recorded in sample QSE. There was no significant difference ($p>0.05$) among the samples except sample WRA. The bulk density ranged from 0.75-0.87 ml/g. The highest value was recorded in sample NMA while the lowest value was recorded in sample MAE and PSU. The values obtained were lower than those reported by previous authors who worked on breadfruit flour; 0.50 ml/g to 1.25 ml/g (Appiah *et al.*, 2011), 2.8 ml/g (Odoemelam, 2005). There was no significant difference ($p>0.05$) between sample NMA, ALT and QSE, MAE and PSU respectively. Bulk density is a measure of the heaviness of a flour sample (Oladele and Aina, 2007). The bulk density of flour used to determine its packaging requirements. It is depending on the particle size and moisture content of flours. Bulk density of composite flour increased with an increase in the incorporation of different flours with wheat flour. The high bulk density of flour suggests their suitability for use in food preparations (liquids, semisolids or solids). The results obtained were higher than the results reported by Kaur and Singh (2005), where they reported the bulk densities of different chickpea cultivars to range from 0.536 g/mL to 0.571 g/mL.

Table 1: Functional Properties of Flour Produced From Soursop Peel and Wheat Composite Flour

SAMPLE	OAC (%)	WAC (%)	Swelling Capacity (%)	Solubility index (%)	Bulk Density (mg/g)
WRA	75.00±3.00 ^a	63.33±1.53 ^a	7.23±0.44 ^b	17.67±0.58 ^b	0.79±0.01 ^b
NMA	82.33±6.11 ^a	66.67±8.51 ^{ab}	6.76±0.47 ^{ab}	13.33±3.06 ^a	0.87±0.00 ^c
MAE	76.00±2.00 ^a	69.33±7.02 ^{ab}	7.09±0.58 ^{ab}	13.67±0.58 ^a	0.75±0.01 ^a
PSU	80.67±2.08 ^a	76.67±1.53 ^{bc}	6.54±0.04 ^{ab}	14.00±2.00 ^a	0.75±0.01 ^a
ALT	83.67±7.78 ^a	80.67±7.37 ^c	7.09±0.16 ^{ab}	14.67±1.16 ^a	0.86±0.02 ^c
QSE	77.33±2.89 ^a	80.00±2.65 ^c	6.41±0.19 ^a	12.67±1.16 ^a	0.86±0.01 ^c

OAC- Oil absorption capacity; WAC – Water absorption capacity *Mean± standard deviation with same superscripts along the column are not significantly different at ($p>0.05$)

KEY : Sample WRA: 100% wheat flour; Sample NMA: 95% wheat flour and 5% soursop peel flour; Sample MAE: 90% wheat flour and 10% soursop peel flour; Sample PSU: 85% wheat flour and 15% soursop peel flour; Sample ALT: 80% wheat flour and 20% soursop peel flour; Sample QSE: 75% wheat flour and 25% soursop peel flour.

Conclusion

Soursop peel and wheat composite flours have functional implications in various percentages. Partial or total substitution of wheat flour with flour of other cereals, legume or oil seeds and peels can serve as a means of diversifying and upgrading local agricultural food products which will therefore result to reduction in level of waste generated from agricultural products. The flours can be used for production of various food products.

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PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF FARO 44, FARO 60, FARO 66, AND FARO 67 RICE VARIETIES

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Abstract

The proximate composition and functional properties of four rice varieties Faro 44, Faro 60, Faro 66 and Faro 67 were determined. The rice paddies were parboiled, DE husked and milled into flour. The four flours were analysed for proximate and functional properties using standard methods. Data obtained were subjected to one way analysis of variance. Results showed that the crude protein, crude fibre and carbohydrate contents of the rice flours varied significantly ($p < 0.05$) while the ash and fat contents had no significant ($p < 0.05$). Furthermore, the functional properties of the flours varied significantly ($p < 0.05$). Results from this study indicate that Faro 44, Faro60, Faro 66 and Faro67 rice varieties possess good levels of protein and carbohydrate contents and also possess good functional properties for use as ingredients in food formulations.

Keywords: *Rice varieties, Functional properties, Proximate composition, Food industry.*

1.0 Introduction

Rice (*Oryza sativa* L.) is a staple food for a large share of the Nigeria's populace (Odenigbo et al 2013). Rice has become an increasingly important crop in many countries in the world and extensively in tropical Africa (Adigboet. al., 2018). It is a member of the Poaceae family and its domestication started from ancient civilisation native to Southeast Asia. Approximately 90% of the rice is grown and consumed in Asia and eleven Asian countries contribute 87% of global rice production. (Bandumula, 2018), Nigeria is one of the leading consumers, producer and importers of rice in the world (FAO 2017). According to Global Agricultural Information Network (2016), the increase in population of Nigeria leads to an expected increase on rice demand and consumption. Nigeria's rice per capita consumption was estimated at 40 kg and it will continue to rise.

Rice is now the main food for about 35 million people in Nigeria, and consumption is increasing faster than that of any other food crop in many countries in Africa (Arijeet. al., 2019). Rice is mainly consumed as a whole grain after cooking which contributes about 40 to 80% of the calorie intake (Thomas et. al., 2013). Niger state where different varieties of rice are being cultivated, is said to be the third largest rice producing state in Nigeria (Merem, 2017).

The objective of this study is to determine the proximate composition and functional properties of the four rice varieties.

2.0 Materials and Methods

All varieties of Rice samples (Faro 44, Faro 60, Faro 66, and Faro 67) were obtained from the rice Breeding Division of National Cereals Research Institute (NCRI), Badeggi, Niger State, Nigeria.

One kilogram of each rice sample was put in a muslin cloth bag and tied loosely before placing inside an air tight plastic container half filled with water for 18 hours. The samples were then removed for steaming in a locally fabricated steaming vessel for 30 minutes. After steaming, the rice (paddies) was dried using solar DehytrayTM dryers. A laboratory model rubber roll rice sheller (THU 35B, Satake Engineering Corp. Tokyo, Japan) with a capacity of 50 kg/h was used to de-husk and mill the rice samples.

2.1 Sample and Data Analyses

The proximate composition and some functional properties of the rice flours were determined using the methods of AOAC (2005) and Onwuka (2005) respectively. The obtained results were analysed statistically using analysis of variance (ANOVA)

3.0 Results and Discussion

The proximate composition of rice flour samples is presented in Table 1.

The moisture contents in the four varieties of rice in this research work ranged between 5.67% and 5.978 %. This outcome is in agreement with most literature for white rice (Otemuyiwa *et al* 2007). Faro 67 has the highest moisture content while Faro 44 has the lowest moisture content. The low moisture content gives it an advantage of long storability without microbial contamination e.g., molds (Oyewole 2007). The difference in moisture content among the rice varieties might be due to the variation in moisture content in the paddy after harvesting or as a result of Faro 67's high water absorption capacity. The range of the moisture content (8.36 % and 10.98%) in this study was under the values reported by (Mbatchou. and Dawda 2013).

Proteins in rice are very essential as proteins form the basic building blocks for cells and tissue repairs in the body (Mbatchou. and Dawda 2013). The protein content range (11.03 % to 12.91 %) in this study is in agreement with the findings by Fari *et al* (2011). The presence of protein influences the nutritional quality of rice (Mbatchou. and Dawda 2013). Faro 67 has the highest crude protein content while Faro 44 has the lowest crude protein content. The variations of protein content in different rice varieties might be due to several factors such as water supply, handling, application of fertilizer, environmental stress (such as salinity and alkalinity, temperatures and diseases), location of growing areas, growing conditions and time which tend to increase the grain protein content. (Michea *et al* 2022)

Fat content influences the taste of cooked rice because rice with high fat tends to be more palatable and have less starch (Hirokadzu *et al* 1979). Fat content in this study were comparatively similar to the ones obtained by Fari *et al* (2011), Oko and Ugwu (2011) and Rohman *et al* (2014). The variations in fat value in rice varieties may be due to oxidation of fat because most fat in rice grains is unsaturated and undergoes oxidation easily by atmospheric oxygen interaction (Hirokadzu *et al* 1979).

The presence of fiber in diet increases the bulk of feces, which has a laxative effect in the gut and aid digestion (Mbatchou. and Dawda 2013). Fiber content in this study agreed with the one obtained by (Thomas *et al* 2013). The percentage fiber contents among the four rice samples were in the range of 1.23 to 1.53%. Although this range is a bit lower than the range 1.93 to 4.3% obtained by Edeogu *et al*. (2007), however, it is similar to the value obtained by Sotelo *et al*. (1990). Faro 67 has the highest crude fiber content while Faro 66 had the lowest crude fiber. Milling of rice generally decreases the fiber contents of rice.

Ash is the inorganic residue remaining after the water and the organic matter have been removed by heating, the ash content of a food sample gives an idea of the mineral elements present in the food sample (Edeogu, *et al* 2007). The Ash content of the rice varieties ranges from 1.35 to 2.00 %. The values of ash in rice recorded in this study is similar to those reported by (Mbatchou. and Dawda 2013). The differences in ash content in the rice varieties may be due to the differences in mineral content of the soils and the water used (Shayo *et al* 2006).

Rice carbohydrates are mainly starch which is composed of amylose and amylopectin. Similar ranges of the carbohydrate contents has been reported (Thomas *et al* 2013) and (Rohman *et al* 2014). The four rice varieties studied in this finding contained a high quantity of carbohydrate ranging from 76.27 % to 78.97 %. Carbohydrate content was high in all the four rice varieties (greater than 76 %) and hence can be considered to be good source of carbohydrate (Thomas *et al* 2013) and hence, a good source of energy.

The functional proprieties of rice samples are shown on Table 2. The rice varieties differed significantly ($P < 0.05$) in all the functional properties evaluated. The Bulk densities of the rice samples analyzed shows that Faro 66 has the highest bulk density (0.90 g/cm^3) while Faro 44 has the lowest bulk density (0.74 g/cm^3). The little changes in bulk density recorded could be attributed to the variations in starch content (Iwe and Onuh, 1992). Bulk density is important as it's a parameter used in determining the flour expansion and porosity of a material that affect the packaging design (Shafi *et al*, 2016b). This result is in accordance with Eze *et al*, (2021).

Water absorption capability refers to the ability by which flour absorb water molecules (Kraithong *et al.*, 2018). The water absorption capacity values of the rice sample flours were 1.49g/g, 1.00g/g, 0.80g/g and 1.80g/g for Faros 44, 60, 66, and 67 varieties respectively. Faro 67 has the highest water absorption capacity while faro 66 has the lowest. These differences can be linked to a high number of hydrophilic groups in the starch molecules, that provide softness, viscosity, and smoothness in food materials (Kraithong *et al.*, 2018)

The result obtained from this study ranges from 0.80 to 1.20 (g/g) with faro 66 having the lowest oil absorption capacity and Faro 44 having the highest oil absorption capacity. Oil absorption capacity is another functional property that helps keep the mouth feels and also the flavor of the food products (Iwe *et al.*, 2016). These recorded values are pointily in line with Sarangapani *et al.* (2016), Iwe *et al.* (2016), and Kraithong *et al.* (2018) who reported similar variation in OAC of rice flour.

The swelling power of the rice samples, Faros 44, 60, 66 and 67, are 75.71%, 79.18 %, 81.12%, and 78.69% respectively. Faro 60 and 67 has the highest Swelling power while faro 44 has the lowest swelling power. Swelling capacity is seen as a very important tool in some food formulations as in bakeries (Iwe *et al.*, 2016).

The foaming capacity of the rice samples was also determined and recorded in Table 1, and the values include 4.81% for Faro 44, 2.99% for Faro 60; 2.64% for Faro 66; 9.98% and 3.43% for Faro 67. Faro 44 has the highest foaming capacity while Faro 66 has the lowest foaming capacity. Foaming capacity. Iwe *et al.* (2016) reported that good foaming capacity and stability are essential for product flours that are to be used to produce varieties of bakery food like biscuits, cakes, bean cakes, cookies, etcetera, and even as functional determinants in various food product formulations. The result obtained is in agreement with the finding

Table 1: Proximate composition of rice flours (%)

Samples	Moisture	Crude Protein	Protein	Crude Fibre	Ash	Crude Fat	Carbohydrate
FARO 44	5.67 ^a ±0.05	11.03 ^b ±0.19		1.26 ^b ±0.05	1.99 ^a ± 0.01	1.49 ^a ±0.49	78.97 ^a ±0.30
FARO 60	5.68 ^a ±0.04	12.48 ^a ±0.37		1.42 ^a ±0.05	2.00 ^a ± 0.00	1.78 ^a ±0.02	76.27 ^b ±0.39
FARO 66	5.90 ^a ±0.10	12.63 ^a ±0.00		1.23 ^b ±0.01	1.35 ^a ± 0.05	1.03 ^a ±0.01	77.86 ^{ab} ±0.17
FARO 67	5.97 ^a ±0.03	12.91 ^a ±0.79		1.53 ^a ±0.10	1.38 ^a ± 0.00	1.09 ^a ±0.02	77.13 ^{ab} ±0.89

Means on the same column with the same superscript are not significantly different at p<0.05

Table 2: Functional properties of rice flour

Samples	BD (g/cm ³)	WAC (g/g)	OAC (g/g)	SP (%)	FC (%)
FARO 44	0.74 ^c ± 0.00	1.49 ^b ± 0.01	1.20 ^a ± 0.00	75.71 ^b ± 0.53 ^b	4.81 ^a ± 0.17
FARO 60	0.85 ^b ± 0.01	1.00 ^c ± 0.00	1.00 ^b ± 0.00	79.18 ^a ± 0.24 ^a	2.99 ^{bc} ± 0.01
FARO 66	0.90 ^a ± 0.01	0.80 ^d ± 0.00	0.80 ^c ± 0.00	81.12 ^a ± 0.00 ^a	2.64 ^c ± 0.03
FARO 67	0.87 ^b ± 0.00	1.80 ^a ± 0.00	1.00 ^b ± 0.00	78.69 ^a ± 0.45 ^a	3.43 ^b ± 0.24

Means on the same column with the same superscript are not significantly different at pc0.05
BD= bulk density; WAC = water absorption capacity; OAC = oil absorption capacity; SP = swelling power; FC = foaming capacity

Conclusion

The result obtained shows that Faro 67 recorded the highest point of 5.97 (%), 12.91 (%), 1.53 (%) for moisture content, crude protein and crude fiber respectively. While Faro 44 recorded highest points for fat (1.49%) and carbohydrate (78.97%) contents. However, Faro 44 had the lowest percentage in terms of moisture content and protein. Faro 66 had lowest percentage of ash, fat and Faro 60 has the least carbohydrate content. Also, it shows that Faro 67 has higher advantage in terms of functionality as it has the highest WAC, SP and low bulk density as flour with low bulk density is suitably served with food and thick textures. Faro 66 has a good percentage of swelling power that makes them good bioproduct for baking and doughy activities when compared with the rest varieties. Oil absorption capacity is an essential functional property of food material that enhances the feel of the mouth and at the same time keeps the flavour of the food products and results obtained indicated such characteristics in Faro 44. Faro 44 also has the best foaming capacity that makes them favorable for baking and doughy activities.

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NUTRITIONAL EVALUATION OF COOKIES PRODUCED FROM WHEAT, AFRICAN WALNUT AND CARROT FLOURS BLENDS

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Abstract

The aim of this work was to evaluate the nutritional content and bioavailability of cookies produced from blends of wheat, African walnut and carrot flour. Cookies were produced from composite flour of wheat, African Walnut and carrot. The wheat flour was substituted at levels of 0, 5, 10, 15 and 20 % with African walnut and carrot flour. Percentage ash, fat, protein and crude fiber content of the cookies increased from 1.10 to 2.15, 18.78 to 24.11, 10.55 to 13.10 and 0.91 to 2.05 %, respectively. with increased substitution of wheat flour with African walnut flour. Energy value increased from 464.10 to 488.47 kcal/100g. *In vitro* protein digestibility of cookies substituted with 15 and 20 % walnut flour increased to 56.55 and 59.64 %, respectively. Calcium, iron and potassium content of the cookies increased from 29.38 to 50.46, 3.75 to 11.36 and 49.20 to 58.90 mg/100g, respectively with increased substitution of walnut and carrot flour blend. Bioavailability of these minerals also increased, however, calcium bioavailability decreased from 55.34 to 43.67 % as walnut flour substitution increased. Substitution of wheat flour with African walnut and carrot flour increased the nutritional value of the cookies.

Keywords: Nutritional, Cookies, Wheat, Walnut, Carrot.

Introduction

Cookies (soft type biscuits) are widely accepted and consumed in many developing countries. In many parts of sub-Sahara Africa and most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products especially biscuits and bread. Cookies and other bakery products have now become loved fast food products for every age-group, because they are easy to carry about, tasty to eat, cholesterol-free, containing digestive and dietary nutrients of vital importance and reasonably cheap. Soft wheat flour used for production of cookies is nutritionally deficient in some vitamins, minerals, as well as dietary fiber. Composite flour has the added advantages of improving the nutrient value of cookies and other bakery products. Non-conventional flours, such as, African walnut flour can present an alternative means of diversifying the use of non-wheat flour as it rich in protein, mineral and polyunsaturated fatty acids, containing about 15 % α -linolenic (omega-3) fatty acid (Kanuet *al.*,

2015). Walnut seed flour has a good potential for use as a functional ingredient agent in bakery products because of its highwater absorption capacity. This shows that the flour is rich in protein and fat and can improve the pasting characteristic and can serve as a protein supplement. Research has also indicated that walnut has anticancer activities (Nagel *et al.*, 2012). Studies indicated that the risk of prostate and breast cancer are reduced by walnut intake (Morgan *et al.*, 2002). It has been demonstrated that walnuts, when consumed as part of a low fat, low-cholesterol diet, have a beneficial effect on serum cardiovascular risk factor (Morgan *et al.*, 2002).

Among vegetables, carrot is the best source of carotene which is the precursor of vitamin A. It is also reported to contain oxycarotenoids such as leutin, which has been shown to be protective against colon cancer in man and woman. This work is thus aimed at substituting wheat flour with African walnut and carrot, to enhance the nutritional value of cookies produced from their blends.

Materials and Methods

Carrots, African walnuts and wheat flour (Dangote all-purpose wheat flour) were purchased from Mile 1 market, Port Harcourt, Rivers State, Nigeria. Carrot flour was produced using the method described by Marvin (2009). The carrot fruit was properly washed, scraped and sliced for easy drying. Water of about 95°C, containing 0.1 % sodium metabisulphite was used for blanching for about 3 minutes, this is to prevent browning and discoloration. The sulphited carrot was immediately cooled by exposing it to air and dried in a cabinet drier (model QUB 305010G, Gallenkamp, UK) at 50°C for 12 hours. The dried carrot was milled into fine powder and sieved (300µm), then stored for further use. African walnut seeds were washed thoroughly to remove sand, boiled at 100 °C for 50 minutes, shelled and cut into slices to facilitate drying. The slices were drained and oven dried at 70°C for 24 hours. The dried slices were milled into flour and sieved to obtain flour of uniform size (300µm). Wheat, African walnut and carrot flours were blended in the following ratios; 100:0:0, 90:5:5, 85:10:5, 80:15:5, 75:20:5 and labeled respectively as samples A, B, C, D and E.

Cookies were prepared according to the method of AACC (2000) with some modification in the recipe. Flour blends (100 g), baking powder (12g), whole egg (20g), salt (1g), fat (50g) and sugar (50g) with 70g water were mixed together to form dough. The dough was cut and baked at 180°C for 15min. Proximate composition (percentage moisture, ash, fat, crude fiber, protein and carbohydrate) was determined using AOAC (2012) standard methods. Energy value was determined using Atwater conversion factor; Energy (kcal/100g) = (9 x protein) + (4 x fat) + (4 x carbohydrate). Mineral analysis was done by dry ashing according to procedure 14.013 of AOAC (2012). Mineral bioavailability of the cookies were determined using method described by Chauhan and Mahjan (1988). About 1.0 g was extracted using 10 ml of 0.03N HCL with shaking at 37 °C for 3 h. Thereafter, the extract was filtered and a clear filtrate obtained was dried at 100 °C and then placed in a muffle furnace at 550°C for 4 h, thereafter the sample

was cooled and about 5 ml of 5N HCL was added and boiled gently for 10 min and then cooled and diluted with 100 ml of distilled water. The supernatant obtained was subjected to mineral analysis using atomic absorption spectrophotometer (AAS). The results obtained were used in calculating the percentage of minerals in the cookies samples that are bioavailable in soluble fractions using the formula:

$$\text{Mineral bioavailability (\%)} = \frac{\text{Mineral extractable in 0.03N HCl} \left(\frac{\text{mg}}{100\text{g}} \right)}{\text{Total Mineral} \left(\frac{\text{mg}}{100\text{g}} \right)} \times 100$$

In-vitro protein digestibility of the samples was determined using the method of Monjula and John (1991). A known weight of each sample containing 16mg nitrogen was taken and digested with 1mg of Pepsin (Cat No. P6887, Sigma chemicals Ltd, USA) in 15ml of 0.1M HCL at 37°C for 3h, the pepsin-hydrolyzed solution was neutralized with 0.5M NaOH and incubated with 6.0mg of pancreatin (Sigma Chemicals Ltd, Cat. No P1750) in 7.5ml of 0.2m phosphate buffer at pH 7.6 for 8h. The reaction was terminated by adding 22.5ml of 10% trichloroacetic acid (TCA). The TCA solution fraction was assayed for Nitrogen using the micro Kjeldahl method. A blank sample was also determined. Protein digestibility was calculated using the formula:

$$\text{Protein digestibility \%} = \frac{\text{Nitrogen in supernatant} - \text{Nitrogen in blank}}{\text{Nitrogen in sample}} \times 100$$

All the analyses were carried out in triplicate. The data obtained were analyzed using analysis of variance (ANOVA) with IBM SPSS version 25 computer software.

Results and Discussion

Result for proximate composition and Invitro protein digestibility of the cookies (Table 1) showed significant ($p < 0.05$) increase in percentage ash, fat, protein and crude fiber content of the cookies with increased substitution of wheat flour with African walnut and carrot flour blends. Higher fat and protein content of African walnut resulted in increased fat and protein content of the cookies. Energy value increased from 465.1 to 487.86 and 488.47 kcal/100g, respectively with 15 and 20 % substitution of Walnut flour. Increased in energy value was probably due to increased fat and protein content. Invitro protein digestibility of cookies substituted with 15 and 20 % walnut flour increased to 56.55 and 59.64 %, respectively. The increase in the values of the substituted samples may be attributed to the highly digestible protein fractions (albumin, globulin, prolamin and glutelin) found in African walnut (Sze-Tao and Sathe 2000).

Result for mineral content and mineral bioavailability of cookies produced from blends of wheat, African walnut and carrot flours as presented in Table 2, showed significant ($p < 0.05$) increase in the mineral content of the cookies, as the percentage substitution of walnut flour increased. Calcium helps in the formation of bones and also provide support and rigidity to skeletal bones. The WHO (2005) daily recommended intake of iron for children (6-59 months) is 5.8 mg/100g. Hence, children can get the required iron from consuming cookies produced with 80, 15 and 5 % blends of wheat, African walnut and carrot flours, and cookies produced

with 75, 20 and 5 % blends of wheat, African walnut and carrot flours. Thus, the substituted products are most adequate for iron supply for children. Sodium content of cookies produced with 80, 15 and 5 % blends of wheat, African walnut and carrot flours was significantly ($p < 0.05$) higher than that of the control (100 % wheat flour cookies). As shown in Table 2, the percentage bioavailability of the Calcium, Iron, Sodium and Potassium in the cookies ranged from 43.67 – 55.34, 22.36 – 37.12, 57.07 – 68.10 and 69.55 – 72.31 %, respectively. Bioavailability is the ability of the body to digest and absorb the mineral in the food consumed. Bioavailability of Iron and Potassium was seen to increase significantly, as the percentage substitution of wheat flour with African walnut and carrot flour increased.

Table 1 Proximate Composition and Invitro Protein Digestibility of Cookies Produced from Wheat, African Walnut and Carrot Flour Blends

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fiber (%)	Carbohydrate (%)	Energy Value (kcal/100g)	IVPD (%)
A	5.44 ^a ±0.64	1.10 ^c ±0.14	18.78 ^b ±0.26	10.55 ^d ±0.35	0.91 ^c ±0.01	63.47 ^a ±0.35	465.1 ^d ±0.95	23.85 ^d ± 0.64
B	5.20 ^a ±0.36	1.72 ^b ±0.04	21.44 ^{ab} ±0.33	11.26 ^{cd} ±0.09	0.89 ^c ±0.00	59.96 ^b ±0.67	477.84 ^c ±0.22	45.20 ^c ± 1.56
C	5.60 ^a ±0.44	1.80 ^b ±0.07	23.20 ^a ±1.77	12.40 ^{bc} ±0.14	1.28 ^{bc} ±0.01	55.83 ^c ±0.16	481.72 ^b ±1.35	55.20 ^b ± 1.27
D	4.57 ^a ±0.64	1.85 ^{ab} ±0.07	24.06 ^a ±0.63	13.55 ^{ab} ±0.78	1.80 ^{ab} ±0.42	54.28 ^{cd} ±0.15	487.86 ^a ±1.34	56.55 ^{ab} ±0.78
E	4.40 ^a ±0.71	2.15 ^a ±0.00	24.11 ^a ±1.20	15.10 ^a ±0.14	2.05 ^a ±0.07	52.77 ^d ±0.81	488.47 ^a ±0.55	59.64 ^a ± 0.76
LSD	0.57	0.08	1.01	0.39	0.19	0.51	2.31	1.06

Mean values are of duplicate determination. Mean values within a column with the same superscript are not significantly different ($p > 0.05$). **Key:** A=wheat flour (100), B=wheat flour + walnut flour + carrot flour (90:5:5), C=wheat flour + walnut flour + carrot flour (85:10:5), D=wheat flour + walnut flour + carrot flour (80:15:5), E=wheat flour + walnut flour + carrot flour (75:20:5), IVPD= Invitro Protein Digestibility

Table 2 Mineral Content (mg/100g) and Mineral Bioavailability (%) of Cookies Produced from Wheat, African Walnut and Carrot Flour Blends

Samples	Calcium		Iron		Sodium		Potassium	
	Content (mg/100g)	Bioavailability (%)	Content (mg/100g)	Bioavailability (%)	Content (mg/100g)	Bioavailability (%)	Content (mg/100g)	Bioavailability (%)
A	29.38 ^c ±0.00	55.34 ^a ±0.07	3.75 ^c ±1.04	22.36 ^{bc} ± 0.01	14.11 ^a ±0.01	57.07 ^d ±0.05	49.20 ^c ±0.29	69.55 ^c ±0.40
B	27.13 ^d ±0.04	55.20 ^a ±0.14	4.48 ^c ±0.00	20.31 ^c ±0.05	15.26 ^{abc} ±0.95	84.86 ^a ±1.21	51.11 ^{bc} ±0.16	71.00 ^{abc} ±0.64
C	40.25 ^b ±1.69	46.88 ^b ±0.17	5.27 ^{bc} ±0.28	23.45 ^{bc} ± 0.14	14.57 ^{bc} ±0.25	68.10 ^b ±1.41	55.22 ^{ab} ±0.64	70.37 ^{bc} ±0.59
D	41.66 ^b ±0.63	43.67 ^c ±0.78	7.10 ^b ±0.05	26.88 ^b ± 0.31	16.08 ^a ±0.91	58.68 ^{cd} ±0.96	56.10 ^a ±1.40	71.49 ^{ab} ±0.18
E	50.46 ^a ±0.19	47.56 ^b ±0.01	11.36 ^a ±0.26	37.12 ^a ± 2.85	15.47 ^{ab} ±0.21	62.66 ^c ±0.77	58.90 ^a ±1.60	72.31 ^a ±0.28
LSD	2.21	0.36	0.5	1.28	1.15	1.00	1.13	0.45

Mean values are of duplicate determination. Mean values within a column with the same superscript are not significantly different ($p > 0.05$).

Conclusion

From the results, ash, protein, fat and crude fiber content of cookies increased with increased substitution of African walnut flour, and inclusion of carrot flour. Protein digestibility, calcium, iron and potassium content were also seen to increase appreciably. Hence, walnut/carrot enriched cookies may be presented as nutritionally enhanced snack, that may serve to alleviate the problem of protein deficiencies in children and for adults who may want to snack on enriched food products. It showed that nutritious cookies can be produced from the composite flour of wheat, African walnut and carrot. This research study indicates that cookies produced from this composite blend contain sufficient percentage of protein, good fat, minimal carbohydrate, and sufficient fiber to supplement deficient nutrient in total wheat cookies, hence can serve as relief for malnutrition.

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PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OFFLOUR BLENDS FROM BITTER YAM (*Dioscoreadumentorum*) AND ACHA FLOURS.

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ABSTRACT

The study investigated the nutritional composition and functional properties of bitteryam with *acha* composite flour blends. The bitteryam tuber was procured from Ogige Market in Nsukka, Enugu State while the acha grains were procured from Jos market, Pleateau state. The bitter yam was peeled, washed, sliced into cubes then, strained and dried in an oven at 60°C for 48hours, while the acha flour was processed under standard procedures. The flour samples were blended at the ratio of 100% acha flour and Unblanchhed bitteryam flour (UBY), UBY/acha blends of 90:10, 80:20, 70:30, 60:40, 50:50. The flour blends samples were analysed for their chemical composition and functional properties. The data obtained were subjected for statistical evaluation. The results obtained revealed that incorporation of acha flour showed significant increase ($p < 0.05$) in the protein, ash, carbohydrate content and energy values of the blends from 8.67 -13.02 %, 1.16-2.02 %, 68.07 -77.16 % and 328.5 -361.4 kcal/100g, respectively. The functional properties showed a significant decline in the water absorption capacity (428.63 -284.83 %), and in the swelling capacity (346.39 -239.62%) with increase in the level of acha flour incorporation.

Keyword: Proximate composition, Functional properties, Bitter yam, *Acha*, Composite flour

INTRODUCTION

Compositing of flours from different plants has been an area of research for many years and has helped in ameliorating malnutrition and essential nutrients deficiencies. Composite flours can be made from a mixture of flour from tubers rich in starch (e.g. cassava, yam, sweet potato etc) and/or flour from legumes rich in protein (e.g. soybeans, peanuts) and/or cereals (e.g. maize, rice, millet, wheat) with or without wheat flour (Adetuyiet *al.*, 2009).

Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured (Kinsella, 1976). Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein (Mattil, 1971).

Bitter yam (*Dioscoreadumentorum*) is a lesser known yam among the yam species and is underutilized. It is easily identified by it trifoliolate leaf. Bitter yam tubers are eaten boiled during the time of famine or scarcity. The high saponin content especially sapogenin in bitter yam (*Dioscorea dumentorum*) makes it good for medicinal purposes.

Digitariaexilis commonly called hungry rice or “acha” is one of the “Lost Crops of Africa” (NRC, 1996). It is described as one of the most nutritious grains and is among the world’s best tasting cereal. Its low glycemic index, has made it recommendable in weaning food and food for diabetic patients (Temple and Bassa, 1991; Ayo and Nkama, 2003). Blending is however known to affect the nutritional composition of the resulting flour. Hence blending of the cereal, acha and the tuber, bitter yam can be used to improve the utilization of the resulting flour more than when the flours are used singly, as the blends could be used in diverse ways during food preparation and processing. Therefore, the study was designed to evaluate the chemical composition and some selected functional properties of bitter yam flour blended with acha flour.

Material and methods:

Fleshy harvested bitter yam (*Dioscorea dumentorum*) and acha grain (*Digitariaexilis*) were purchased from a local market in Nsukka of Enugu state, Nigeria.

Preparation of the samples

The bitter yam was washed, peeled and diced into cubes and dried in an hot air oven at 50°C for 48 hours while the acha grain was winnowed, sorted to remove the debris of stones and foreign material, washed, dried and grinded into flour and packaged for packaged for further analyses.

Formulation of the flour blends

The flour samples from the bitter yam and *acha* flour were blended at varied ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 respectively

Analyses of the sample

The proximate composition of the flour samples was determined using the standard methods of Association of Official Analytical Chemists (AOAC, 2010). The crude protein content was determined by the micro Kjeldahl nitrogen method and the nitrogen content was converted to protein using a 6.25 conversion factor. Carbohydrate content was determined by difference. The energy value was calculated by application of the thermal coefficients of Atwater and Rosa (1899). The selected functional properties water absorption capacity and swelling capacity were carried out using the method described by Lin *et al.* (1974) and the bulk density of the samples were determined according to the procedure outlined by Nwanekezi (2001)

Experimental design and Statistical Analysis

The study adopted a complete random design. Data obtained were in triplicate values and were analysed using SPSS package version (21). Differences between means were calculated by analysis of variance and means separation was done using Duncan’s Multiple Range Test and statistical significance was accepted at ($p < 0.05$).

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of bitter yam with acha flour blend. There were significant differences ($p < 0.05$) among the bitter yamacha blends. The moisture, fat and crude fibre content of the flour samples showed a decrease with increase in acha level (6.19 -4.44 %, 1.19 -0.44 %, 1.19 -0.44 %).

2.63 -0.28 % and 4.20-1.08%). The decrease in the moisture content value with increase in acha substitution as observed could be attributed to the low moisture content in acha flour (7.06 %) which could have caused a dilution effect on the blends. Increase in acha flour inclusion shows an increase in the protein, ash and carbohydrate (10.76-13.47%, 1.17 -2.82 % and 73.28-80.17 %) contents of the flour blends. This increase in ash content as acha flour increased shows that acha flour is a good source of mineral.

Blending ratio of acha to bitter yam flour had a significant effect on the moisture content of the samples. The moisture content of the flour blends ranged from (6.19- 4.44 %) with increase in the level of acha incorporation. Acha as a grain also contains starch and other non nitrogenous components that may have mopped up the available moisture in the bitter yam thus reducing the determined moisture. Holdsworth (1983) noted that moisture level below 15 to 16 % is desirable to prevent bacterial growth, while moisture levels below 10 % is required to prevent mould growth. This implies that all the flours produced can be stored without spoilage and likewise blending of acha with bitter yam will enhance the keeping quality of the flour during storage. The protein contents of the flour ranged from 10.76 to 13.47 % with sample containing 100% untreated bitter yam flour (UBY₀) having the least protein content of (10.76 %) and the highest in sample with 50:50 bitter yam and acha blends (13.47%). The protein values observed in this study is comparable to the content (10.84 %) reported by Adelekan *et al.* (2013). Increasing the level of acha incorporation increased the protein content of the flour blends though acha has been reported to be low in protein (7.0 to 9.0 %) compared to bitter yam (Ogbonnaya and Aminat, 2008; Jideani *et al.*, 1994). The observed increase in protein level of the blends with increase in acha incorporation may be due to an apparent decrease in moisture content.

Table 1: Proximate composition and energy value of bitter yam and acha flour composites (%)

Blends	Moisture	Fat	Crude fibre	Total ash	Crude Protein	Carbohydrate	Energy kcal/100g
UBY ₀	6.19 ^e ±0.06	2.63 ^a ±0.05	4.20 ^c ±0.01	1.17 ^h ±0.00	10.76 ^c ±0.30	73.28 ^d ±0.12	359.8 ^{bc} ±0.5
UBY ₁₀	5.58 ^f ±0.25	2.16 ^c ±0.03	2.73 ^f ±0.07	1.86 ^f ±0.02	11.77 ^d ±0.00	74.60 ^e ±0.15	364.9 ^b ±5.1
UBY ₂₀	5.54 ^f ±0.33	1.06 ^d ±0.05	2.20 ^g ±0.03	2.13 ^d ±0.00	11.88 ^d ±0.11	76.53 ^b ±0.14	363.2 ^b ±2.4
UBY ₃₀	5.11 ^g ±0.11	0.84 ^f ±0.03	2.08 ^h ±0.05	2.61 ^c ±0.05	12.66 ^c ±0.99	77.10 ^b ±0.06	366.6 ^b ±0.9
UBY ₄₀	4.88 ^g ±0.03	0.62 ^g ±0.10	1.29 ⁱ ±0.03	2.77 ^b ±0.00	13.16 ^b ±0.06	77.21 ^b ±0.32	367.1 ^b ±3.7
UBY ₅₀	4.44 ^h ±0.04	0.28 ^h ±0.10	1.08 ^k ±0.03	2.82 ^a ±0.00	13.47 ^a ±0.04	80.17 ^a ±1.00	377.1 ^a ±3.0
Acha	7.90 ^d ±0.77	1.27 ^d ±0.03	2.01 ^a ±0.20	2.58 ^c ±0.24	6.92 ⁱ ±0.07	76.34 ^b ±0.06	344.41 ^g ±2.25

Values are means of triplicate determination $\pm$ SD. Means in the same column with different superscripts are significantly different ($p < 0.05$).

Key: UBY₀= 100 % Unblanched bitter yam UBY₁₀= fed 90:10 Unblanched bitter yam:acha blend; UBY₂₀= 80:20 Unblanched bitter yam:acha blend; UBY₃₀= 70:30 Unblanched bitter yam:acha blend; UBY₄₀= 60:40 Unblanched bitter yam:acha blend; UBY₅₀= 50:50 Unblanched bitter yam:acha blend.

Functional properties of bitter yam samples and their blends with acha flour

Table 2 shows the result of the selected functional properties. A significant difference ($p < 0.05$) in the bulk density (BD), water absorption capacity (WAC) and swelling capacity (SWC) were observed. The bulk density of the flour blends ranged from 0.51 g/cm³ to 0.77 g/cm³. A remarkable increase was observed in bulk density as the level of acha inclusion increased. The sample containing a percentage of 50:50 of bitter yam, acha blends (UBY₅₀) had the highest bulk density value of 0.77 g/cm³ while unblended ratio (UBY₀) had the least value 0.51 g/cm³. This shows that the sample blend UBY₅₀ is denser than the other flour blends. Blending bitter yam with acha flour increased the bulk density and reduced the water absorption capacity (477.51 - 337.71 %) and swelling capacity (445.0 - 227.81 %) of the flour blends with increase in acha inclusion. The highest bulk density value of 0.77 g/cm³ observed in sample UBY₀ was relatively higher than the value (0.68 g/cm³) reported by Adelekan *et al.* (2013) but lower than the value (0.87 g/cm³) reported by Ezeocha *et al.* (2011). Bulk density is influenced by particle size and the density of the flour which is also important in determining the packaging requirement and material handling (Karuna *et al.*, 1996). The high WAC and SWC observed with unblended sample were higher when compared with bitter yam:acha flour blends, this indicates that sole bitter yam flour required more water to form dough than the flour blend. This trend of functional properties observed, showed that higher bulk density is indirectly related to WAC and swelling capacity. However, all the flour blends showed good water absorption capacity and therefore could be incorporated into aqueous food formulations especially those that required hydration to improve handling (Giami, 1993). Karuna *et al.* (1996) noted that swelling capacity decreases as particle size increases and is one of the quality criterion used in choosing functional ingredient for bakery products and in complementary food formulations. It is also an indication of the absorption index capacity of the flour granules during heating (Adelekan *et al.*, 2013).

Table 2: Functional Property of bitter yam and acha Flour blends

Blends	Bulk density (g/cm ³)	Water absorption capacity (%)	Swelling capacity (%)
UBY0	0.51 ^g ±0.00	477.51 ^a ±0.79	445.0 ^a ±3.50
UBY10	0.51 ^g ±0.00	476.51 ^a ±0.79	357.23 ^b ±2.54
UBY20	0.56 ^f ±0.00	403.77 ^c ±5.32	319.23 ^c ±8.21
UBY30	0.68 ^e ±0.00	386.60 ^d ±11.68	242.43 ^{gh} ±4.42
UBY40	0.71 ^b ±0.00	344.43 ^f ±6.64	231.80 ^h ±3.32
UBY50	0.77 ^a ±0.00	337.71 ^g ±6.64	227.81 ⁱ ±1.03
Acha	0.58 ^e ±0.00	215.83 ⁱ ±8.09	150.96 ^j ±2.25

Values are means of triplicate determinations ± SD. Means in the same column with different superscripts are significantly different ($p < 0.05$). **Key:** UBY₀= 100 % Unblanched bitter yam UBY₁₀= fed 90:10 Unblanched bitter yam:acha blend; UBY₂₀= 80:20 Unblanched bitter yam:acha blend; UBY₃₀= 70:30 Unblanched bitter yam:acha blend; UBY₄₀= 60:40 Unblanched bitter yam:acha blend; UBY₅₀= 50:50 Unblanched bitter yam:acha blend;

CONCLUSION:

The blends of bitter yam:acha showed significant ($p < 0.05$) increases in protein, ash, and carbohydrate but decreases in moisture, fat, and crude fibre contents with increase in acha inclusion. A significant decrease was also observed in the water absorption capacity and the swelling capacity and an increase in the bulk density. This shows that compositing of acha flour with bitter yam could improve the nutritional composition and functional properties of the flour sample and hence could be adopted in food formulations.

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CONSUMER ACCEPTABILITY OF PEARL MILLET-COWPEA AND SORGHUM-COWPEA EXTRUDED PUFFED SNACK

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Abstract

Extrusion cooking is one of the technologies that provide several options for production of gluten-free safe and nutritious snacks. This study evaluated the consumer acceptability of pearl millet-cowpea and sorghum-cowpea extruded puffed snack. Pearl millet grains and sorghum grains were sorted, washed, dried and milled into flour, while cowpea was briefly soaked in water for 5 min at room temperature (28 °C) to loosen the seed coats, dehulled manually, dried and milled into flour. Pearl millet flour was mixed with cowpea flour in the ratio (100%, 50:50%, 62.5:37.5%, 75:25% and 87.5:12.5%) while sorghum was mixed with cowpea flour in the ratio (100%, 50:50%, 62.5:37.5%, 75:25% and 87.5:12.5%) using a mixer with the incorporation of other ingredients such as sugar, flavour and water. The mixture was extruded into puff snack. Results showed a significant ($p < 0.05$) decrease in the colour of the extruded puffed as the quantity of cowpea flour increase while taste, aroma and overall acceptability increased with a decrease in the quantity of cowpea flour for the extruded snack. Samples A and F had higher values for all sensory parameters and were most preferred among all samples evaluated for consumer acceptability.

Keywords: Pearl millet, Sorghum, Extrusion, Snack, Consumer acceptability

Introduction

Food insecurity in developing countries and the high cost of commercially produced extruded snack foods from composite flour hinders the reduction of protein deficiency and malnutrition. Therefore, there is a need to improve the nutritional status of snack foods. Flour blending has been identified as one of the methods which aids the improvement of the micronutrient composition of cereal flours [1]. In addition to increasing the nutrient composition of food products, flour blending also enhances the rheological, sensory and physical properties [2]. Extrusion is a food processing method that has been widely used in the production of pasta, breakfast cereals and snacks [3]. Typically, commercial snack products are made of cereal flours and starches, and further seasoned with oil slurries with a resulting product usually high in fat and carbohydrate contents, and low in proteins and fibre content [4]. Extruded puffed snacks produced from gluten free cereals such as pearl millet and sorghum blended with cowpea become a safe and nutritious product for both children, young and old adults. This study investigated the consumer acceptability of extruded puffed snack produced from pearl millet-cowpea and sorghum-cowpea composite flour.

Materials and Methods

Materials

Pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*), sugar and flavour were purchased from Kuto market in Abeokuta, Ogun State, Nigeria. The extruded puffed snack was produced using a twin-screw extruder at the Industrial Park Unit, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Methods

Pearl millet grains and sorghum grains were sorted and washed with portable water. The cleaned cereal grains were dried separately in a cabinet dryer (DC774, Jinan KeySong Machinery Co., Ltd, Gaoxin district, Jinan, China) at 60 °C for 24 h to a moisture content of about 10%. The dried grains were milled and sieved through 500 µm aperture size. The cowpea was briefly soaked in water for 5 min at room temperature (28 °C) to loosen the seed coats, dehulled manually and dried in the cabinet dryer for 4 h. The dried cowpea was milled and passed through a sieve to obtain a flour. Pearl millet flour was mixed with cowpea flour in the following ratios (100%, 50:50%, 62.5:37.5%, 75:25% and 87.5:12.5%) and sorghum was mixed with cowpea flour in the following ratios (100%, 50:50%, 62.5:37.5%, 75:25% and 87.5:12.5%) using a mixer (D50-Qt, Jinan KeySong Machinery Co., Ltd, Gaoxin district, Jinan, China) with incorporation sugar, flavour and water. Each mixture was adjusted to a moisture content of 12% (wet basis) with portable water. The mixture was extruded into puffed extruded snacks using a co-rotating twin-screw extruder (XTS56-Xtrutech, Jinan KeySong Machinery Co., Ltd, Gaoxin district, Jinan, China) with three independent cooking zones of temperature 50, 120 and 140 °C respectively, constant screw speed of 150 rpm and a die diameter of 8 mm. The extruded puffed snacks were collected and packaged into sterile polyethylene bags. Sensory evaluation was carried out in the Sensory Analysis Laboratory, Department of Food Science and Technology, Federal University of Agriculture, Abeokuta. One hundred and fifty (150) semi-trained panelists were asked to evaluate the extruded puffed snack based on its appearance, flavour, taste, texture and overall acceptability using nine-point hedonic scale (1 = dislike extremely to 9 = like extremely) as described by the modified method of Deshpande and Poshadri [5]. All experimental data were collected in three replicates and analysed with SPSS 21.0 software package (IBM, Chicago, IL, USA) by one-way analysis of variance (ANOVA). The mean values were separated at 5% significance level using Duncan Multiple Range Test (DMRT).

Results and Discussion

There was a significant ($p < 0.05$) difference observed between the composite extruded puffed snack for all sensory attributes (Table 1). Samples A and F were most preferred among all samples evaluated for consumer acceptability. The decrease in the mean score of the pearl millet-cowpea extruded puffed snack for appearance can be attributed to a gradual increase in the quantity of cowpea flour. Appearance is an important physical parameter to be observed for extruded products and is also a good quality factor related to the acceptability of food products [6]. Similarly, taste and aroma were shown to increase with a decrease in the quantity

of cowpea flour for both pearl millet-cowpea extruded puffed snack and sorghum-cowpea extruded puffed snack. This signifies that the panelists were not too comfortable with the beany flavour in the snack. Samples A and F had higher values in flavour and crunchiness for both pearl millet-cowpea extruded puffed snack and sorghum-cowpea extruded puffed snack. The result further indicated that the values for the overall acceptability increased with a decrease in the quantity of cowpea flour for both pearl millet-cowpea extruded puffed snack and sorghum-cowpea extruded puffed snack.

Table 1: Mean score for consumer acceptability of extruded puffed snack from pearl millet-cowpea and sorghum-cowpea composite flour.

Samples	Appearance	Taste	Aroma	Flavour	Crunchiness	Overall acceptability
A	6.77±1.73 ^b	6.65±1.83 ^c	5.83±1.95 ^b	5.36±1.87 ^b	6.29±2.17 ^c	6.65±1.77 ^c
B	5.32±2.00 ^a	4.63±1.78 ^a	4.52±2.21 ^a	5.26±2.31 ^{ab}	5.88±2.17 ^{bc}	5.62±1.81 ^a
C	4.88±1.96 ^a	4.97±2.37 ^a	4.66±1.85 ^a	4.99±2.28 ^{ab}	5.38±1.75 ^{ab}	5.72±1.93 ^a
D	4.97±2.1 ^a	5.01±1.89 ^a	4.72±1.97 ^a	4.59±2.13 ^a	5.21±1.90 ^a	6.1±1.57 ^{ab}
E	5.38±1.93 ^a	5.92±2.11 ^b	4.88±2.20 ^a	4.96±2.46 ^{ab}	5.37±2.15 ^{ab}	6.42±1.48 ^{bc}
F	5.64±1.96 ^b	6.47±2.13 ^b	5.1±1.51 ^b	5.71±2.03 ^c	6.27±2.13 ^b	6.74±2.15 ^c
G	5.01±1.93 ^a	5.25±1.81 ^a	3.95±1.65 ^a	5.08±2.42 ^{ab}	5.51±1.55 ^a	5.07±2.07 ^a
H	4.89±2.08 ^a	5.25±2.11 ^a	4.71±1.57 ^b	5.5±2.00 ^{bc}	5.75±2.1 ^{ab}	5.33±2.06 ^a
I	4.72±1.95 ^a	5.26±2.02 ^a	5.03±2.18 ^b	5.05±1.97 ^{ab}	5.34±1.92 ^a	5.91±1.82 ^b
J	4.93±2.22 ^a	5.48±1.77 ^a	5.09±2.12 ^b	4.83±1.91 ^a	5.35±2.32 ^a	6.16±1.67 ^b

Mean values with different superscript within the same column are significantly different ($p < 0.05$)

A: 100% pearl millet, B: 50% pearl millet: 50% cowpea, C: 62.5% pearl millet: 37.5% cowpea, D: 75% pearl millet: 25% cowpea, E: 87.5% pearl millet: 12.5% cowpea, F: 100% sorghum, G: 50% sorghum: 50% cowpea, H: 62.5% sorghum: 37.5% cowpea, I: 75% sorghum: 25% cowpea, J: 87.5% sorghum: 12.5% cowpea

Conclusion

The sensory properties of the snacks were significantly ($p < 0.05$) affected by the addition of cowpea flour. Pearl millet extruded puffed snack produced from 100% pearl millet flour and 100% sorghum extruded puffed snack had higher values for all sensory parameters and was most preferred among all samples evaluated for consumer acceptability.

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ANTIOXIDANT ACTIVITIES OF FLOURS FROM FOUR NIGERIAN RICE CULTIVARS

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Abstract

This study investigated the phytochemical constituents and antioxidant properties of four Nigerian local rice cultivars (*Bisalaye*, *MaduYankpa*, *Sipi*, and *Sharugi*). Rice paddy from the cultivars were dehulled and milled into flour using standard procedure. The total phenolic content (TPC), total flavonoid content (TFC), total anthocyanin content (TAC), 1,1-diphenyl-2-picrylhydrazil (DPPH) radical scavenging activity, and ferric reducing antioxidant power (FRAP) of the rice flours were determined using standard methods of analysis. Results obtained revealed that the TPC, TFC, TAC, DPPH and FRAP ranged ($p \leq 0.05$) from 1.36 to 2.01 mg GAE/g, 41.53 to 48.92 mg CE/g, 1.14 to 1.60 mg/100 g, 81.90 to 87.41% and 0.85 to 1.37 mg TE/g, respectively. In addition, it was established that the antioxidant activities of the rice samples were in the order: *Sipi* > *MaduYankpa* > *Bisalaye* > *Sharugi*. Therefore, the rice cultivars are rich sources of phytochemicals and bioactive constituents for utilization in food systems. This drives the recommendation for detailed profiling of the nutritional composition, physico-chemical and techno-functional properties of the flours for specific use in food product development.

Keywords: Nigerian rice, Indigenous cultivars, Phytochemical constituents, Antioxidant Potential

1.0 Introduction

Rice is the most important cereal crop in the developing world and the most staple food of over half the world's population (Liu, 2018). Rice flour is gluten-free with unique properties for diverse food applications. Nigeria is one of the largest producers of rice in Africa. There are several local rice varieties cultivated in Nigeria, which serve as source of food and income for the rural farmers. These rice varieties are cultivated alongside the improved varieties by farmers; thus, have potential to contributing to nutrition and food security in Africa.

In recent times, there is renewed interest in the consumption of local varieties of rice due to their low starch content and higher bioactive properties (Chinma *et al.*, 2015). There are reports that local rice varieties play a significant role in the promotion of health and wellness because of the abundance of micronutrients and bioactive constituents (Devraj *et al.*, 2020). In addition, the use of gluten-free cereals rich in phenolic compounds and antioxidant activities in the development of functional gluten-free cereal-based foods is gaining global interest due to their

health benefits (Rocchetti *et al.*, 2019). Nevertheless, there is paucity of information on the quality characteristics including antioxidant properties of Nigeria's local rice varieties in comparison to rice varieties from other major rice producing countries of the world such as China, Thailand, USA, among others. The objective of this study was to determine the phytochemical constituents and *in vitro* antioxidant properties of four Nigerian rice cultivars. Such information is expected to increase the utilization and potential of the rice cultivars for the promotion of food and nutrition security in Africa.

2.0 Materials and methods

2.1 Materials

Four Nigerian rice varieties (*Bisalaye*, *MaduYankpa*, *Sipi*, and *Sharugi*) were procured from National Cereal Research Institute Badeggi, Bida Niger State, Nigeria. All chemicals used were of analytical grade.

2.2 Preparation of rice flour

The rice flour was prepared as described by Chinma *et al.* (2018). Briefly, 2 kg of rice paddy from each cultivar were separately dehusked in a Satake rice husker (THU-35B, Satake Corporation, Japan) and brown rice samples obtained were polished in a Satake grain testing mill (model No. 553504, Satake Engineering Co., Japan) to obtain 8% degree of milling. Afterwards, rice grains from each cultivar were separately milled in a hammer mill (Globe P 44, Diamond Tools Co. Ltd. Henan, China), sieved (mesh size 100 µm) and stored in airtight plastic containers covered with lids.

2.3 Profiling of total phenolic content and antioxidant potential

A standard procedure (Chinma *et al.*, 2014) was adopted in the preparation of methanolic extract (ME) used for profiling total phenolics and antioxidant activities. Accordingly, sample (0.2 g) was mixed with 4 mL of 80% methanol, and the mixture was centrifuged (at 4000 × g for 20 min). Afterwards, the supernatant was transferred into test tubes, evaporated (under nitrogen stream) and stored (at 4 °C). Samples were extracted in triplicate. The methanolic extracts of the samples were used for the analysis of total phenolic content (TPC), total flavonoid content (TFC) and antioxidant activities. The TPC was determined according to Folin–Ciocalteu reagent method as explained by Chinma *et al.* (2014) and expressed as mg GAE/g. The TFC was determined according to the method of Reddy *et al.* (2016) and reported as mg CE/g. The TAC (total monomeric-anthocyanin concentration) was assayed by the pH-differential procedure described by Sutharut and Sudarat (2012). The DPPH (1,1-diphenyl-2-picrylhydrazil) radical scavenging activity and ferric reducing antioxidant power (FRAP) were determined as described by Chinma *et al.* (2014).

2.4 Statistical analysis

Results obtained were subjected to analysis of variance using a statistical software (SPSS 20, BM, Armonk, NY, USA). Tukey's test was used to determine significant differences (5% probability) among means.

3.0 Results and Discussion

The antioxidant activities of four Nigerian rice cultivars differed significantly ($p \leq 0.05$) (Table 1) and the results of the antioxidant parameters are above the values previously reported by Chinma *et al.* (2015) for some Nigerian rice cultivars (*Jamila*, *Jeep* and *Kwandala* which contained 1.05 to 1.18 mg/GAE/g TPC and 1.01-1.04 mgmmol TE/g FRAP) as well as a popular Indian white rice variety, *Karudan samba* (1.91 mg GAE/ g TPC, 42.33 mg CE/g TFC, 82.56% DPPH and 0.83mg AAE/g reducing antioxidant power) (Meera *et al.*, 2019). It was observed that *Sipi* had the highest TPC, TFC, TAC, DPPH and FRAP while *Sharugi* had the lowest value (Table 1). It was also observed that antioxidant activities of the rice cultivars were in the order: *Sipi* > *MaduYankpa* > *Bisalaye* > *Sharugi*, which corroborates that antioxidant capacity is associated with the concentration of phytochemicals in food materials. Moreover, phytochemical constituents have enormous antioxidant potential for the promotion of health and wellness (Mir *et al.*, 2016). From this perspective, the four Nigerian rice cultivars have potential health properties which could be utilized in the development of novel g foods.

4.0 Conclusions

This study demonstrated that the four Nigerian rice cultivars are rich sources of phytochemicals and bioactive compounds. The study established that the antioxidant potential of the rice cultivars were in the order: *Sipi* > *MaduYankpa* > *Bisalaye* > *Sharugi*. Nevertheless, information on the functionality of the flours is relatively scarce for specific use in product development. In the light of this, research is on-going in our laboratory on the nutritional composition, physicochemical and techno-functional properties of the rice flours in order to effectively utilize the flours in specific food formulation.

Table 1. Antioxidant activities of rice flour from four Nigerian rice varieties

Parameter	<i>Bisalaye</i>	<i>MaduYankpa</i>	<i>Sipi</i>	<i>Sharugi</i>
TPC (mg GAE/g)	1.54±0.01 ^c	1.79±0.01 ^b	2.01±0.02 ^a	1.36±0.01 ^d
Total flavonoid (mg CE/g)	44.67±0.22 ^c	47.36±0.19 ^b	48.92±0.23 ^a	41.53±0.27 ^d
Total anthocyanin (mg/100 g)	1.31±0.01 ^c	1.45±0.01 ^b	1.60±0.01 ^a	1.14±0.02 ^d
DPPH (%)	82.54±0.13 ^c	84.23±0.19 ^b	87.41±0.25 ^a	81.90±0.20 ^d
FRAP (mg TE/g)	1.02±0.01 ^c	1.16±0.01 ^b	1.37±0.01 ^a	0.85±0.17 ^d

The data from triplicate experiments are expressed as a mean ± standard deviation.

Values with different superscripts in a row are significantly different ($p \leq 0.05$).

TPC = Total phenolic content, TFC = Total flavonoid content, TAC = Total anthocyanin content, DPPH = 1,1-diphenyl-2-picryl-hydrazyl radical scavenging activity, and FRAP = Ferric reducing antioxidant power.

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IMPACT OF FERMENTATION ON THE BIOCHEMICAL PROPERTIES, ANTINUTRITIONAL COMPOUNDS AND ANTIOXIDANT ACTIVITIES OF GELATINIZED FLOURS FROM TWO FONIO VARIETIES

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Abstract

The impact of fermentation on the biochemical properties, antinutritional compounds and antioxidant activities of gelatinized flours from white and brown fonio grains were investigated. The gelatinized flour was fermented at different periods (2, 4, 8, 16 and 24 h) using *Saccharomyces cerevisiae*. Flour samples with moderate acidity were produced following gelatinization, and combined fermentation and gelatinization. Gelatinization significantly ($p \leq 0.05$) reduced the level of phytic acid, tannin and saponin content in both varieties compared to the raw flour. In a time dependent manner, fermentation led to substantial reduction ($p \leq 0.05$) in antinutritional compounds, and improved phytochemical constituents (total phenolic content and total flavonoids content) and antioxidant activities of the gelatinized fonio flours. This study demonstrated that combined fermentation with *Saccharomyces cerevisiae* and gelatinization could be utilized to produce fonio flour with low residual antinutrients and higher antioxidant activities.

Keywords: White and brown fonio grains, Fermentation, Gelatinization, Antinutritional Compounds,

Antioxidant capacity

1.0 Introduction

Cereal grains form the major portion of the diet of the global population. Wholegrain cereals provide an affordable and accessible nutritional foundation (Erenstein *et al.*, 2022). White fonio (*Digitaria exilis*) and brown fonio (*Digitaria iburua*) are the two commonly cultivated fonio varieties in West Africa (Agu *et al.*, 2020), are attracting research attention due to their low gluten content and glycemic index and rich phytochemicals, encouraging their use in functional foods formulation (Adams and Yakubu, 2020). Fonio grains are rich in macro- and micronutrients as well as phytochemicals for human nutrition, with chemical compositions similar to other cereals and pseudo-cereals (Zhu, 2020). On the other hand, antinutritional compounds such as phytate present in fonio grains significantly reduce bioavailability of nutrients (Zhu, 2020), which limits its use in food system. Therefore, processing is a prerequisite for the consumption of whole grains.

Several traditional and novel food processing methods have been employed to reduce the level of antinutritional compounds and improve the nutritional quality of cereals including whole grains. Research has established that biotechnological approach combining gelatinization and fermentation caused significant reduction in the concentration of antinutritional compounds,

improved the nutritional, antioxidant and technological properties of grains for the development of functional foods (De Pasquale *et al.*, 2020). Accordingly, fermentation involves biochemical changes that occur in the macromolecules of the food materials by the action of microorganism-derived enzymes, thus, modifying the functionality of the derived product. In this study, the effect of fermentation on the biochemical properties, antinutritional factors and antioxidant activities of two fonio varieties (white fonio, *Digitaria exilis* and brown fonio, *Digitaria iburua*) were evaluated.

2.0 Materials and Methods

2.1 Materials

The white and brown fonio grains were purchased from an Agro seed Company in Minna Central Market, Minna, Nigeria. Chemicals and reagents were procured from a reputable Agrochemical industry in Minna and Abuja

2.2 Sample preparation

Two fonio varieties (white and brown varieties) were prepared the same way. Cleaned fonio grains were washed in clean tap water, drained, and dried in air draft-oven (Gallenkamp, Cheshire, UK) at 50 °C for 24 h. The dried BGN grains were milled (Globe P 44, Diamond Tools Co. Ltd. Henan, China) and sieved (mesh size of 100 µm) to produce raw flour.

For the gelatinized flour, fonio grains from the two varieties were separately washed in cold tap water and thereafter soaked in cold tap water (1: 5 w/v) for about 4 h at room temperature (28 ± 1 °C), drained and the soaked seeds was steamed at 100 °C for 20 min. Afterwards, the steamed grains were oven dried at 50 °C for 24 h and milled in a hammer mill (Globe P 44, Diamond Tools Co. Ltd. Henan, China) and sieved using a mesh size of 100 µm to obtain gelatinized fonio flour.

The fermented-gelatinized flour samples were prepared as follows: 1 g of baker's yeast was dissolved in 100 mL of distilled water. The mixture was then added to 100 g of the flour to act as starter. The batter was fermented at 37 °C in a fermentation cabinet (National MEG Company, Lincoln, USA) at different periods (0, 2, 4, 8, 16 and 24 h). The fermented batter was dried in an oven at 50 °C for 24 h and the dried flour was blended and sieved (to pass through 100 µm screen) to produce fermented-gelatinized flour.

2.3 Determination of pH and total titratable acidity

The pH of the fonio flours were determined by homogenizing 10 g of respective flours with 90 mL distilled water and determination using a calibrated pH meter (PHS-25, Techmel, USA). Afterwards, the filtered slurry of the sample was used to determine the titratable acidity (%), which was titrated against 0.05 M NaOH solution with phenolphthalein as an indicator (Azeez *et al.*, 2022).

2.3 Determination of antinutritional factors

Phytic acid and tannin content in the samples were assayed as reported by Azeez *et al.* (2022) while total saponin was assayed by a method reported by Lai *et al.* (2013). The phytic acid, tannin and saponin content results were reported as mg/100 g, CE/mg and mg/ 100g, respectively, on dry weight basis.

2.4 Determination of phytochemical constituents and antioxidant properties

The samples extracts (methanolic extract) of the flour samples were assayed for the determination of total phenolic content (TPC) and antioxidant activities (DPPH and ABTS radical scavenging activities) according to a method reported by Chinma *et al.* (2014). Total phenolic content was determined following by the Folin–Ciocalteu reagent method (Chinma *et al.*, 2014), presented as mg GAE/g. The TFC was assayed following a standard procedure (Sant’Anna *et al.*, 2005) and presented as mg CE/g. The DPPH (1,1-diphenyl-2-picryl-hydrazil) radical scavenging activity and ABTS (2,2'-Azino-bis-3-ethylbenzthiazoline-6-sulfonic acid) were profiled as reported by Chinma *et al.* (2014) and Sant’Anna *et al.*, 2016), respectively.

2.5 Statistical analysis

Data obtained in this study were subjected to analysis of variance using a statistical software (SPSS 20, BM, Armonk, NY, USA). Tukey’s test was also employed to determine significant differences at 5% probability level among means.

3. Results and Discussion

3.1 pH and TTA of raw, gelatinized, and gelatinized-fermented fonio flours

A drop in pH was recorded in the gelatinized, and gelatinized-fermented samples compared to the raw samples from white and brown fonio grains (Table 1). In a time dependent manner, fermentation led to significant reduction in pH with a corresponding increase in total titratable acidity in gelatinized fonio samples compared to the control. Such decrease in pH values and corresponding increase in TTA, may partly be attributed to hydrolysis of starch into organic acids by microorganisms. The moderate pH range recorded in treated fonio samples is within the optimum pH of some food enzymes (such as α -amylase, protease, phytase, and β -glucanase), and such pH could make them activated and improve the quality attributes of food products (Ilowefah *et al.*, 2017). Moreover, higher total titratable acidity of the fermented-gelatinized white and brown fonio flours may inhibit the proliferation of undesirable microorganisms that may cause poor fermentation of the fonio grains. This may influence the functionality of the flour. Therefore, such information should be established in future studies.

3.2 Antinutritional composition of raw, gelatinized, and gelatinized-fermented fonio flours

The antinutritional composition of raw, gelatinized, and fermented-gelatinized fonio flour samples are presented in Table 1. The level of antinutritional compounds (phytic acid, tannin and saponin) were significantly ($p \leq 0.05$) reduced in gelatinized fonio flours from both varieties compared to the raw flour, probably due to hydrothermal effect that caused degradation of the antinutritional compounds. In addition, the soaking of the grains in water probably facilitated the leaching-out of the antinutritional compounds in water. In a time dependent manner, fermentation caused an enormous reduction ($p \leq 0.05$) (in the level of antinutrient compounds probably due to increased activities of microorganisms and or enzymes that caused hydrolysis of ANFs; thus, in accordance with the report where significant reduction in ANFs were recorded following lactic acid fermentation of legume flours (De Pasquale *et al.*, 2020). The level of residual antinutrients obtained in this study following gelatinization, and combined gelatinization and fermentation were much lower than the concentration recommended as safe level for human consumption (Farinde *et al.*, 2018).

3.3 Antioxidant activities of raw, gelatinized, and gelatinized-fermented fonio flours

Total phenolic content and total flavonoids content of the raw flour from brown variety was significantly higher than the white fonio. Table 1 shows that the TPC and TFC of the gelatinized samples were significantly higher than the raw flour. Compared to the raw flour from both varieties, fermentation caused significant increase in TPC and TFC of the flours probably due to the increased activities of microorganism/microbial enzymes that caused the release of phenolics which also accounted for increase total flavonoids content. The increased TPC and TFC probably caused significant increase in the antioxidant properties of gelatinized, and combined fermented and gelatinized fonio flours from both varieties. The fermented-gelatinized flour had high antioxidant activities followed by the gelatinized flour, and the control. In addition, the brown fonio samples had higher antioxidant activities than the white fonio.

Conclusions

This study revealed that the moderate acidity of the gelatinized, and fermented-gelatinized fonio flours indicated that the flours could be incorporated in food formulations. The study established that fermentation could be sufficient to produce gelatinized fonio flours with low residual antinutritional compounds and higher antioxidant activities. Further studies are needed to provide insight on the impact of fermentation on the nutritional, functional and structural properties of gelatinized flours from white and brown fonio grains for specific food application.

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Table 1. Effect of fermentation on the biochemical properties, antinutritional compounds and antioxidant activities of gelatinized flours from two fonio varieties (white and brown)

Parameters	FT	pH	TTA (mL)	Phytic (mg / 100 g)	Tannin (mg CE/g)	Saponin (mg/100 g)	TPC (mg GAE/g)	TFC (mg CE/g)	DPPH (μmol TE/g)	ABTS (μmol TE/g)
White fonio	raw	6.05±0.01 ^a	0.50±0.00 ^c	520.13±1.42 ^b	0.27±0.02 ^a	6.44±0.04 ^c	1.45±0.01 ^b	5.37 ± 0.02 ^a	12.60±0.01 ⁱ	21.19±0.02 ^a
	0 (GF)	5.89±0.01 ^b	0.67±0.01 ^d	474.05±1.17 ^a	0.18±0.01 ^b	5.98±0.02 ^a	1.63±0.01 ^a	5.50±0.01 ⁱ	12.97±0.01 ^b	21.70±0.06 ⁱ
	2	5.64±0.00 ^c	0.89±0.01 ^c	423.07±1.29 ^a	0.15±0.01 ^b	5.61± 0.03 ^a	1.70±0.01 ^a	5.65±0.01 ⁱ	13.24±0.01 ^a	21.99±0.03 ⁱ
	4	5.57±0.01 ^c	1.07±0.01 ^b	380.56±1.10 ^a	0.13±0.01 ^b	5.39±0.01 ^a	1.84±0.02 ^a	5.97±0.02 ^a	13.48±0.03 ^a	22.26±0.05 ^a
	8	5.54±0.00 ^c	1.17±0.01 ^{ab}	326.93±1.25 ⁱ	0.10±0.01 ^{bc}	4.85±0.01 ^a	1.97±0.01 ^a	6.13±0.01 ^a	13.70±0.03 ^a	22.64±0.02 ^a
	16	5.49±0.00 ^c	1.20±0.01 ^{ab}	257.45 ±1.36 ⁱ	0.07±0.01 ^c	4.40±0.03 ^a	2.15±0.01 ^a	6.60 ±0.01 ^a	13.95±0.02 ^a	22.88±0.07 ^a
Brown fonio	24	5.46±0.01 ^c	1.18±0.01 ^{ab}	203.60±1.14 ^c	0.07±0.01 ^c	3.81±0.01 ⁱ	2.33±0.01 ^a	7.05±0.01 ^a	14.28±0.03 ^a	23.50±0.04 ^a
	raw	6.11±0.00 ^a	0.52± 0.02 ^a	552.40±1.23 ^a	0.31±0.01 ^a	6.92±0.05 ^a	1.67±0.01 ^a	5.83±0.00 ^b	13.21±0.01 ^a	22.35±0.01 ^a
	0 (GF)	5.94±0.01 ^b	0.70±0.01 ^d	496.52±1.21 ^a	0.20±0.01 ^b	6.64±0.02 ^b	1.90±0.03 ^a	6.24±0.01 ^a	13.50±0.00 ^a	22.83±0.03 ^a
	2	5.63±0.01 ^c	0.98±0.01 ^c	463.17±1.17 ^a	0.18±0.01 ^b	6.30±0.01 ^a	2.03±0.01 ^a	6.57±0.01 ^a	13.66±0.01 ^a	23.20±0.06 ^a
	4	5.60±0.01 ^c	1.09±0.00 ^b	397.84±1.19 ^a	0.16±0.00 ^b	5.92±0.01 ^a	2.17±0.01 ^a	6.79±0.01 ^a	13.98±0.01 ^a	23.61±0.02 ^a
	8	5.58±0.01 ^c	1.19±0.01 ^{ab}	341.13±1.12 ⁱ	0.14±0.00 ^b	5.54±0.03 ^a	2.28±0.02 ^a	6.96±0.02 ^a	14.23±0.03 ^a	23.96±0.05 ^a
	16	5.53±0.01 ^c	1.24±0.01 ^a	285.62±1.15 ^a	0.11±0.01 ^b	4.77±0.01 ^a	2.45±0.01 ^b	7.27±0.01 ^b	14.49±0.03 ^b	24.17±0.01 ^b
	24	5.48±0.01 ^c	1.27±0.01 ^a	239.25±1.04 ^{am}	0.10±0.01 ^b	4.14±0.01 ⁱ	2.59±0.00 ^b	7.64±0.04 ^a	14.85±0.03 ^a	24.43±0.04 ^a

Data presented as means ± standard deviation from triplicate analysis. Means with no common letters within a column are significantly different at (p≤0.05).

DPPH: 2,2-diphenyl-1-picrylhydrazyl; ABTS= 2,2'-Azino-bis-3-ethylbenzthiazoline-6-sulfonic acid, FT= Fermentation time; GF = Gelatinized flour

CHAPTER 3

LEGUMES PROCESSING AND PRODUCTS

PROXIMATE COMPOSITION, AMINO ACID AND SENSORY PROFILES OF ANALOGUE FOOD CONDIMENTS FROM FERMENTED BAMBARA NUT, PEANUT, PIGEON PEA AND AFRICAN YAM BEAN GRAIN LEGUMES.

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Abstract

The fermentation of underutilized, neglected grain legumes for making food condiment analogue to increase availability and replace chemical based/synthetic condiments that hamper health of consumers was investigated. Bambara nut, African yam bean, Peanut and pigeon pea legumes were obtained, separately prepared and fermented using two modified traditional fermentation techniques (moistened banana leaf and cocoa sack) to produce eight (8) condiment samples, while commercial locust bean condiment was used as control. The samples were coded, including Bambara nut condiment (BNC 1&2), African yam bean (AYB 1&2), Peanut condiment (PNC 1&2), Pigeon pea (PPC 1&2) and locust bean condiment (LBC) and subjected to nutrients composition, amino sensory profile determinations and statistical data analysis using standard methods. There were variations in nutrients of the condiment samples, protein (23.94 – 32.05% range) highest value for BNC1; fat (1.50 – 22.48% PNC2, highest); Ash (1.00 – 5.85%, LBC with highest value), carbohydrates (39.85 – 59.60, highest and lowest in BNC1 and PPC2 respectively), total essential amino acids (27.3 – 37.07g/100g protein, non-essential amino acids (48.75 – 59.69g/100g protein). Taste (6.5 – 7.0), colour (5.7 – 6.9) attributes for condiments from Bambara nut, African yam bean and Pigeon pea are similar to locust bean (control), and not affected by the fermentation material/medium. Flavour of pigeon pea condiment, PPC 1&2 (6.8 – 6.9) ranked highest, followed by Bambara nut, African yam bean and Peanut (the least) which was significantly different ($p < 0.05$). Apparently, pigeon pea and African yam bean condiments are found to be the most suitable alternatives to the traditional locust bean condiment in terms of nutrients content and organoleptic/sensory properties.

Keywords: Food condiment, Fermentation, Legumes, Nutrients, Amino acid, Sensory properties.

Introduction

Food condiment refers to peculiar ingredient that imparts and contributes characteristic flavour, aroma and some macro/micro nutrients to food usually added during food preparation for consumption (Hornby, 2001). It is glutamic acid-based, which is available in certain protein moieties. Conventional food condiments are produced by the fermentation of some grain legumes to yield high glutamic amino acid, which adds flavours and characteristic aroma to food, including Africa locust bean (iru), melon (ogiri), soybean (Dawadawa). Odunfa, (1988), Adama (2021). Most common food condiments are chemical-based/synthetics, such as Monosodium glutamate (MSG), Onga, Maggi cubes and many more. Cumulative residuals in the body constitute health risk to consumers. Available records show that about 1.55 million metric tons assorted food condiments are consumed annually in Nigeria (NBS, 2017). There is need for variety of food condiments, especially organics to safe guard consumers' health and widen choices due to ever growing population and civilization (Ademola *et al.*, 2011). There is necessity for value addition to underutilized legumes (e.g pigeon pea, African yam bean,

peanut) to produce industrial food ingredients for economic gains to the processors and farmers. Organic/natural food condiments are dense in protein (22 – 57%), vitamins, but low in fat, can be presented in various forms, dry, coarse, granules, powder, sauce and packaged in hermetic containers (Igbatigbi, 2012 and Orishagbemi, 2016). Research reports have been made available on the elimination of undesirable flavouring in locust bean and soy condiments, whereby ginger, scent leaf, lemon grass have been incorporated to absorb and mask such flavour (Adama, 2021). Therefore, objectives of this research work were to: produce food condiment analogues from underutilized/neglected legumes (Bambara nut, African yam bean, peanut and pigeon pea) using natural micro flora from moistened leaf and cocoa sack, determine nutrients composition, including amino acid profile and determine sensory/organoleptic properties of condiments produced to ascertain suitability.

Materials and Methods

Samples of Bambara nut (*Vigna subterranean* L), African yam bean (*Sphenostylis stenocarpa*), pigeon pea (*Cajanus cajan* L) and peanut (*Arachis hypogea*) grains were purchased from retailers at Anyigba central market, Kogi State. They were identified by experts. The seeds of each legume were separately prepared into coarse particles, pressure cooked (100g/3L water) for 45 mins and drained. While still hot, each was divided into two equal portions for fermentation (4 days) using two methods (calabash lined with moistened dry banana leaves for one portion and cocoa sack for second portion as sources of microbial culture for fermentation, similar to traditional method of locust bean fermentation, such microorganisms included corynebacterium glutamicum, lysinucum; lactic acid bacteria such as Leuconostoc, streptococcus, lactobacillus, enterococcus, pediococcus, aerococcus spp. Yeast (e.g. Saccharomyces, Kluyveromyces, Debaryomyces species), moulds (Penicillium, Geotrichum, Rhizopus species). Igbatigbi (2012), Omoniwakole (2022) and Odunfa (1988).

The food condiment samples (eight) were each grinded, molded and dried (60°C, in cabinet dryer with fan), cooled and packaged in heat sealed High density polyethylene (HDPE, 0.5mm gauge). Commercial locust bean condiment (iru) was obtained and used as control sample. Each condiment sample was subjected to nutrients composition evaluation, including amino acids, sensory profile and data analysis using standard methods (AOAC, 2010; Orishagbemi, 2021).

Results and Discussion

The proximate composition of analogue/ imitation food condiments

Table 1 shows the nutrients contents of analogue/imitation food condiments produced

Table 1: Proximate compositions of analogue food condiments from Bambaranut (BNC), African Yam Bean (AYB), Pea nut (PNC), Pigeon Pea (PPC) and Locust bean, LBC (control)

Sample	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Total Carbohydrate (%)
BNC1	7.76±0.22 ^a	32.05±0.14 ^d	11.62±0.01 ^g	4.41±0.46 ^j	4.31±0.11 ^l	39.85±0.60 ⁿ
BNC2	7.85±0.14 ^a	31.65±0.13 ^d	10.87±0.03 ^g	3.82±0.41 ⁱ	4.21±0.25 ^l	41.60±0.12 ⁿ
AYB1	8.05±0.41 ^a	29.32±0.42 ^d	9.70±0.31 ^g	3.19±0.26 ^j	4.11±0.09 ^l	54.37±0.21 ^o
AYB2	8.15±1.42 ^a	27.21±0.52 ^e	9.51±0.21 ^g	3.21±0.01 ⁱ	4.61±0.11 ^l	47.31±0.22 ^o
PNC1	4.85±0.07 ^b	26.41±0.04 ^e	20.75±0.07 ^h	0.89±0.07 ^k	1.08±0.04 ^m	49.75±0.02 ^o
PNC2	4.57±0.04 ^b	23.94±0.06 ^f	22.48±0.01 ^h	0.85±0.01 ^k	1.00±0.00 ^m	47.48±0.03 ^o
PPC1	9.93±0.03 ^c	27.08±0.01 ^e	1.50±0.00 ⁱ	1.03±0.02 ^k	1.18±0.01 ^m	59.30±0.12 ^p
PPC2	9.36±0.13 ^c	28.76±0.2 ^e	1.67±0.05 ⁱ	4.86±0.25 ^j	5.85±0.12 ^l	40.85±0.30 ⁿ

LBC (control)	12.30±0.14 ^c	24.13±0.03 ^f	10.32±0.32 ^g	1.10±0.01 ^k	1.20±0.00 ^m	59.60±0.21 ^p

Values are means ±SD of triplicate determinations (SD = Standard Deviation).

Means in a column with the same superscripts are not significantly ($p < 0.05$) different.

Code:

1 – Fermented using moistened dry banana leaf

2 – Fermented using moistened cocoa sack.

Moisture content ranged from 4.57% (PNC sample) to 12.30% (LBC control sample) which showed significant ($p < 0.05$) variation among the legumes used. Traditional LBC (control) has highest M.C. (12.30%) due to sun drying method used (30+2°C) while others dried in cabinet dryer at 60°C, have lower M.C. (low water activity), due to higher drying temperature and can keep longer. The extent of biochemical complexes formed which could bound moisture can lead to either increased or reduced moisture content (as in PNC, BNC, AYB and PPC samples). Similar observation and reports were made by Osman (2013), Hassan et al., (2015) in their work on fermented soybean and melon condiments respectively. Protein content was highest in bambara condiment (31 – 32.05%), followed by African yam bean (AYB), locust bean (control) and peanut condiment with lowest value, PNC2 (23.94%). Condiments fermented with banana leaf have higher protein content in all samples, showing that it is more suitable than cocoa sack, providing the required natural microbial culture for fermentation. Higher protein content in samples fermented with moistened banana leaf might be due to the availability of appropriate natural microflora responsible for fermentation and subsequent conversion of greater metabolites resulting into higher proteins and amino acids especially glutamic acid.

Highest fat content occurred in PNC samples (20.00-22.88%), then follow BNC and LBC (10.81-11.62%), AYB (9.51-9.90%) and the lowest, PPC (1.50-1.67%) showing significant difference. Differential in fat content is due to legume commodity effect. The crude fibre and ash contents are generally low and not affected by fermentation, while carbohydrates were very high in all the condiment samples (39-59% regardless of the legume, and with variation of little or no significance ($p < 0.05$) which could be due to the use of simple carbohydrates present during fermentation.

Amino acid profiles (Essential and Non-essential) of Condiments

The essential and non-essential amino acid contents of imitation food condiment samples produced are presented in table 2.

Table 2: Amino acid profiles of analogue food condiments from Bambara nut (BNC), African Yam Bean (AYB), Peanut (PNC), Pigeon pea (PPC) and locust beans (LBC)

Essential Amino acid (g/100g protein)	BNC1	BNC2	AYB1	AYB2	Samples PNC1	PNC2	PPC1	PPC2	LBC
Lysine	5.75 ^a ± 0.01	5.43 ^a ±0.03	4.96 ^a ±0.000	4.80 ^a ±0.11	3.50 ^a ±0.10	3.29 ^a ±0.04	7.15 ^a ±0.11	6.78 ^a ±0.11	5.20 ^a ±0.02
Isolencine	4.01 ^a ± 0.11	3.85 ^a ±0.01	2.89 ^a ±0.02	2.81 ^a ±0.01	2.58 ^a ±0.12	2.71 ^a ± 0.11	5.84 ^a ±0.02	5.29 ^a ±0.01	3.25 ^a ± 0.13
Phenylalanine	3.95 ^a ± 0.01	3.64 ^a ±0.01	2.99 ^a ±0.03	2.41 ^a ±0.02	2.56 ^a ±0.01	2.36 ^a ±0.00	4.85 ^a ±0.10	4.72 ^a ± 0.11	3.37 ^a ± 0.04
Leucine	6.03 ^a ± 0.00	5.82 ^a ±0.12	4.64 ^a ±0.01	4.61 ^a ±0.02	5.22 ^a ±0.10	3.98 ^a ±0.03	8.01 ^a ±0.00	7.90 ^a ±0.01	5.38 ^a ± 0.07
Tryptophan	0.87 ^a ± 0.02	0.78 ^a ±0.01	0.72 ^a ±0.07	0.68 ^a ±0.02	0.6 ^a ±0.11	0.55 ^a ±0.04	1.02 ^a ±0.01	1.25 ^a ± 0.01	0.72 ^a ± 0.00
Valine	4.85 ^a ± 0.00	4.55 ^a ±0.03	3.78 ^a ±0.01	3.67 ^a ±0.12	2.51 ^a ±0.05	1.98 ^a ±0.01	4.95 ^a ±0.00	3.8 ^a ± 0.00	4.01 ^a ± 0.02
Methionine	1.25 ^a ± 0.02	1.10 ^a ±0.00	0.68 ^a ±0.01	0.59 ^a ±0.07	1.30 ^a ±0.03	1.06 ^a ±0.01	2.21 ^a ±0.10	1.96 ^a ± 0.02	0.85 ^a ± 0.00
Treonine	3.10 ^a ± 0.00	3.01 ^a ±0.02	2.66 ^a ±0.01	2.32 ^a ±0.04	1.89 ^a ±0.10	1.93 ^a ±0.03	3.77 ^a ±0.01	3.46 ^a ±0.07	2.47 ^a ±0.00
Arginine	5.01 ^a ± 0.09	4.45 ^a ±0.02	4.13 ^a ±0.02	3.89 ^a ±0.05	3.57 ^a ±0.10	3.50 ^a ±0.06	6.67 ^a ±0.01	7.11 ^a ±0.05	4.54 ^a ± 0.01
Histidine	2.25 ^a ± 0.01	2.00 ^a ±0.02	1.75 ^a ±0.00	1.49 ^a ±0.01	1.72 ^a ±0.12	1.33 ^a ±0.10	3.11 ^a ±0.02	3.42 ^a ±0.01	2.00 ^a ± 0.13
Total EAA	37.07 ^a ± 0.02	34.62 ^a ±0.03	29.20 ^a ±0.11	27.32 ^a ±0.01	22.43 ^a ± 0.12	20.16 ^a ±0.21	42.30 ^a ±0.13	38.55 ^a ±0.02	31.79 ^a ±0.15
<u>Non essential amino acid</u>									
Glutamic acid	15.78 ^a ± 0.11	15.38 ^a ±0.14	14.64 ^a ±0.07	14.65 ^a ±0.07	11.74 ^a ±0.11	10.82 ^a ±0.21	20.10 ^a ±0.16	17.32 ^a ±0.14	12.15 ^a ±0.10
Aspartic acid	22.03 ^a ± 0.20	21.84 ^a ±0.19	19.52 ^a ±0.13	17.23 ^a ±0.13	14.12 ^a ±0.11	10.91 ^a ±0.13	18.48 ^a ±0.22	21.22 ^a ±0.16	17.90 ^a ±0.13
Alanine	4.78 ^a ± 0.01	4.55 ^a ±0.03	3.89 ^a ±0.10	3.89 ^a ±0.10	2.86 ^a ±0.01	2.11 ^a ±0.00	8.15 ^a ±0.11	7.84 ^a ± 0.03	4.52 ^a ±0.01

Values are means +SD of triplicate determinations (SD= standard deviation) Means in a row with the same super scripts are not sig.(p<0.05) different.

code:

- 1 - Fermented using mositered dry banana leaf
- 2 - Fermented using moistered cocoa sack

Lysine content is highest in PPC (7.15g/100g protein), then BNC, LBC (control) and lowest in PNC (3.21/100g protein), showing significant (p<0.05) difference. Leucine and valine values followed similar pattern in the samples as Lysine. While Tryptophan, Methionine and Histidine values are very low (0.55-2.25g/100g protein) in all the samples. Probably because the organismsinvolved in fermentation used up some parts for cell growth and energy. It was found that samples fermented using moistened banana leaf yielded greater quantity of amino acids than the others fermented using moistened sack, regardless of the type of legume involved. This shows that moistened leaf furnished more available and appropriate natural microflora responsible for fermentation and subsequent conversion of metabolites resulting into higher protein and amino acids, especially lysine, leucine, glutamic and aspartic acids. The leaf mighty also provide condition for enhanced fermentation temperature while this is retained due to non-porous nature of leaf. Variation in the yield of protein amino acids in fermented molon using pure culture of corynebacterium species has been reported (Omfaube et al., 2015), which is similar to this result using natural microflora (mixed culture).

Both Glutamic and Aspartic acids are higher in all the condiment samples, especially PPC, BNC and AYB. which contributed to the cherishable flavor property of pigeon pea and Bambara and African bean condiments, better than the locust bean (control).

Sensory profiles of food condiments

Table 3 shows the mean sensory attribute scores of food condiments produced (colour, taste, flavor texture).

Table 3: Mean sensory attribute scores of Analogus food condiments from Bambaranut (BNC), African Yam Bean (AYB), Peanut (PNC), Pigeon pea (PPC) and Locust bean LBC (Control).

Samples	Sensory Attributes				
	Colour	Taste	Flavour	Texture	Overall acceptability
BNC1	7.8±0.14 ^a	7.2±0.22 ^e	6.2±0.31 ^g	7.3±0.02 ^h	7.6±0.16 ^k
BNC21	7.5±0.08 ^a	7.1±0.18 ^e	7.4±0.12 ^f	7.5±0.11 ^h	7.8±0.20 ^k
AYB1	7.0±0.16 ^a	7.4±0.09 ^e	7.2±0.06 ^f	7.3±0.08 ^h	7.7±0.01 ^k
AYB2	7.2±0.21 ^a	7.3±0.17 ^e	7.4±0.12 ^f	7.1±0.05 ^h	7.3±0.10 ^k
PNC1	6.2±0.11 ^b	5.3±0.13 ^d	5.7±0.09 ^g	6.1±0.02 ⁱ	5.6±0.17 ^j
PNC2	5.7±0.13 ^c	5.5±0.06 ^d	5.6±0.11 ^g	6.0±0.13 ⁱ	5.7±0.08 ^j
PPC1	7.6±0.06 ^a	7.3±0.02 ^e	7.6±0.05 ^f	7.8±0.01 ^h	7.5±0.08 ^k
PPC2	7.3±0.04 ^a	7.3±0.11 ^e	7.7±0.07 ^f	7.5±0.01 ^h	7.4±0.12 ^k
LBC (Control)	6.7±0.12 ^a	7.0±0.05 ^e	6.2±0.08 ^g	6.4±0.08 ⁱ	6.5±0.03 ^f

Values are means, n = 15 panelists ±SD (SD = Standard Deviation)

Mean in a column with the same superscripts are not significantly (p<0.05) different.

Code:

- 1 – Fermented using moistened dry banana leaf
- 2 – Fermented using moistened cocoa sack.

The taste (7.0 – 7.4 score range) and colour (7.3 – 7.8 range) of BNC, AYB and PPC are similar to that of the LBC (control sample) and significantly (p<0.05) different from samples PNC, but not objectionable. The unfermented soluble carbohydrate contents must have contributed to the taste attribute which varies among the samples. Also, natural brown pigment of peanut in PNC sample has contributed to its colour. Each condiment has its characteristic flavour, which is most cherishable in PPC 1&2 condiment samples, with high flavour scores (7.6 – 7.7). Apparently, PPC, AYB and BNC are suitable alternatives to the popular locust bean condiment (iru) due to the available nutrients and sensory properties.

Conclusion

Desirable food condiment analogues have been produced from some underutilized legumes (Bambaranut, African yam bean, pigeon pea), similar to the traditional locust bean condiment. The nutrients content and sensory properties of these condiment samples were characterized and pigeon pea condiment is the most suitable as alternative.

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EFFECT OF SELECTED PRESERVATIVES ON NUTRITIONAL COMPOSITIONS OF SOYBEAN SEEDS

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ABSTRACT

Studies to determine the effect of preservatives on soybean seeds are vital. The effect of the preservatives, dichlorvos (2,2- Dichlorovinyl-Dimethyl Phosphate), pepper, and ash from complete combustion of Neem stem, on nutrient levels of soybean seeds, were determined, using the standard procedures. Proximate analysis conducted, showed a significant difference in crude fibre content in sample preserved with dichlorvos. Samples preserved with ash and pepper showed relatively less changes in crude fibre content. The fat and crude protein contents were not significantly ($P \geq 0.05$) affected by ash and pepper preservatives. There was a significant decrease in moisture content in samples preserved with pepper and ash. Carbohydrate content showed a significant increase ($P \leq 0.05$) in all the preserved samples. On the mineral profile, the results showed that there were significant ($P \leq 0.05$) decrease in iron, magnesium, calcium and zinc content for samples preserved with pepper. However, there were significant ($P \leq 0.05$) increase in potassium and magnesium for samples preserved with ash. The amino acid profile conducted, showed a significant ($P \leq 0.05$) decrease in the amino acid composition of the samples preserved with pepper and Dichlorvos, but less significant difference in the sample preserved with ash.

Keywords: Soybean, Preservatives, Ash, Dichlorvos, Pepper

Introduction

Soybean (*Glycinemax*), also called Soja bean is an annual legume of pea family (Fabaceae). Grain legumes also called pulses, play an important role in the nutrition of many people due to their high protein content. They represent a major source of protein in many developing countries, especially among the poorest population, and are rich in essential amino acids such as lysine, supplementing thus the nutritional value of cereal and tuber diets (Graham and Vance, 2003).

Preservatives are food additives used to inhibit the growth of microorganisms like yeast, molds and bacteria. They prevent spoilage by different anti oxidative reactions in order to preserve the appearance, nutritional characteristics and prolongation of time that the food can be stored. It can also be added to product such as pharmaceutical drugs, paints, biological samples, cosmetics, wood, and many others to prevent decomposition by microbial growth or by undesirable chemical changes (Abdulummeen *et al.*, 2012). Preservation is applied in two modes: chemical and physical. Chemical preservation entails adding chemical compounds to the products. Physical preservation entails processes such as refrigeration or drying. Several

forms of chemical preservatives are being used in food and beverage industries. However, some of these chemical preservatives may have harmful effect on the farm produce and its nutritional qualities (Mirza *et al.*, 2017). Dichlorvo also called sniper is an organophosphate insecticide, used in crops, animals and in pest-strips. It has high aqueous solubility and degradable. It is used in the concentration of six or twelve parts per million (Binukumar and Grill, 2010). Currently, there are increased demands for to decrease synthetic preservatives in foods and instead use natural and healthy alternatives, Bird's eye pepper has antimicrobial, antifungal and prebiotic properties. It can make a good seasoning and act as a preservative for seed and grains (Berke and Shieh, 2001). Wood ash contains natural salts that repels pest. It inhibits the growth of the pathogenic fungi. Its hygroscopic nature can be used to maintain low seed moisture and prolong the shelf life of seed (Adekunle and Uma, 2005).

MATERIALS AND METHOD

Materials

The mature soybean seeds (*Glycine max*) were collected from the area of cultivation in Doma, Doma Local Government Area, Nasarawa State, Nigeria.

Dichlorvos or 2, 2-dichlorovinyl dimethyl phosphate (DDVP) also known as Sniper was obtained from standard agro-allied store in Keffi, Nasarawa. Ash was gotten from a complete burning of the stem of Neem tree (*Azadirachta indica*). The ash was sieved to remove sand and other impurities. One hundred and fifty (150)g was weighed and packed in polyethylene bag. Fresh birds eye pepper (*Capsicum frutescens*) was purchased from the market and dried in the sun. One hundred and fifty (150) g of the sun-dried pepper was weighed and packed in a polyethylene bag.

Methods

Exactly 200 g of the cleaned soybean seeds were weighed into each of the four buckets with tight lids.

A bucket of soybean seeds with no preservative/ treatment served as control, the second contained soybean seeds mixed with sixty (60) g of birds eye pepper, the third bucket contained soybean seeds mixed with sixty (60) g of ash. The fourth bucket contained soybeans mixed with zero point two (2) ml of DDVP.

The seeds were stored at temperature of between 25 to 27°C for a period of six (6) months and properly labeled. All through the storage period the seeds were checked on monthly intervals. After the six months period, each treatment were washed with clean water, (the seed coats removed) and dried to ensure all the preservatives are out before processing the samples for laboratory analysis. All treated including the control were milled into powder. The powdered soybean seeds were then stored for laboratory analysis.

PROXIMATE COMPOSITION ANALYSIS

The powdered samples were analyzed for moisture, protein, fat, ash, fiber and nitrogen free extract by the methods prescribed by AOAC, 2005 and Carbohydrate content was obtained by difference, thus subtracting the sum of crude protein, fat, ash, crude fibre and moisture contents from 100.

MICRONUTRIENT ANALYSIS

Determination of minerals such as Iron (Fe), Zinc (Zn), Manganese (Mn) and Magnesium (Mg) were carried out using Atomic Absorption Spectrometry. Soybean samples were analyzed for nutrients including potassium, sodium, calcium, magnesium, iron, zinc, copper and cobalt by following the AOAC, 2005 method. Sample was initially acid-digested and analyzed using the atomic absorption spectrophotometer. The amino acid profile was also determined using the method described by AOAC 2005.

Statistical Analysis

Data generated in triplicates were subjected to analysis of variance using SPSS version 21 statistical packages. Means were separated using Fisher's least significant difference and expressed as mean $\pm$ standard deviation. Significant differences are expressed at $P < 0.05$.

RESULTS AND DISCUSSIONS

Proximate Composition and mineral content of soybeans

The proximate composition and mineral content of soybean treated with birds eye pepper, ash and 0.2 ml of DDVP are shown in Table 1.

Table 1: Effect of Dichlorvos (2,2- Dichlorovinyl Dimethyl Phosphate) Pepper, and Neem-stem Ash on Proximate composition and Mineral content of Soybeans{mg/g}

Proximate content (%)	CONTROL	DDVP	Ash	Pepper
Crude protein	40.24 $\pm$ 0.05	40.38 $\pm$ 0.10	39.61 $\pm$ 0.03	40.15 $\pm$ 0.17
Fat	17.54 $\pm$ 0.04	16.55 $\pm$ 0.13	17.33 $\pm$ 0.05	19.29 $\pm$ 0.35*
Ash	5.41 $\pm$ 0.02	5.12 $\pm$ 0.02	4.53 $\pm$ 0.21*	5.62 $\pm$ 0.34
Crude fibre	5.73 $\pm$ 0.02	6.01 $\pm$ 0.10	5.30 $\pm$ 0.12	5.12 $\pm$ 0.05
Moisture	3.37 $\pm$ 0.14	2.23 $\pm$ 0.06	0.99 $\pm$ 0.03	1.25 $\pm$ 0.05
Carbohydrate	27.71 $\pm$ 0.69	29.71 $\pm$ 0.59*	33.24 $\pm$ 0.68*	28.57 $\pm$ 0.05
Minerals (mg/g)				
Zn	2.01 $\pm$ 0.00	1.90 $\pm$ 0.00	1.08 $\pm$ 0.00	0.97 $\pm$ 0.00*
Fe	5.09 $\pm$ 0.00	5.04 $\pm$ 0.00	4.31 $\pm$ 0.00	3.86 $\pm$ 0.00*
K	107.49 $\pm$ 0.00	107.49 $\pm$ 00.0	112.33 $\pm$ 0.00*	106.87 $\pm$ 0.00
Mg	92.59 $\pm$ 0.00	93.91 $\pm$ 0.87	102.23 $\pm$ 0.00*	90.73 $\pm$ 0.00
Ca	25.50 $\pm$ 0.00	24.57 $\pm$ 0.00	24.86 $\pm$ 0.00	21.51 $\pm$ 0.00*

The proximate analysis of this study gave a result similar to that reported by Asibuo *et al.*, (2008). There is a significant ($P \leq 0.05$) increase with the value **19.29 $\pm$ 0.35*** in fat content for sample preserved with pepper when compared with samples of no preservative with the value **17.54 $\pm$ 0.04*** which served as control. This could be as a result of the pepper having a positive effect on the fat content. There was a significant difference in crude fibre content in sample preserved with DDVP while ash and pepper show relatively less changes in crude fibre

content, the fat and crude protein contents are unaffected by ash and pepper respectively, there is no significant difference $P < 0.05$ in crude protein and fat content. This may be due to the fact that pepper and ash have no effect on either the fat or crude protein content of the legume. There was a significant decrease in moisture content in samples preserved with pepper and ash 3.37 ± 0.14 , 2.23 ± 0.06 , $0.99 \pm 0.03^*$, 1.25 ± 0.05 this might be attributed to the preservative quality of pepper and ash since microbes require moisture in their environment to thrive. Ash hygroscopic nature can be used to maintain low seed moisture and prolong the shelf life of the seeds. Carbohydrate content shows a significant increase ($P \leq 0.05$) in all samples preserved probably due to less moisture content in relation to carbohydrate this is in contrast to that reported by Asibuo *et al.*, (2008) 27.71 ± 0.69 , $27.71 \pm 0.69^*$, $33.24 \pm 0.668^*$, 28.57 ± 0.04 .

The mineral content for soya bean illustrated in Table 1, showed a significant ($P \leq 0.05$) decrease in iron content for samples preserved with pepper, in contrast to that reported by Asibuo *et al.*, (2008) this could be due the effect of the components of pepper on iron content in soybean. Iron is an important mineral which forms an important constituent of hemoglobin, the oxygen carrying pigment of the red blood cell for cellular metabolism.

A significant ($P < 0.05$) decrease in zinc content was observed in the group preserved with pepper, zinc is an important trace mineral which plays a role in cell division, growth, wound healing, and the breakdown of carbohydrate (Sekler *et al.*, 2007). Potassium contents of soybean showed a significant ($P > 0.05$) increase for sample preserved with ash. Potassium is an essential mineral in maintaining cellular function (Penton *et al.*, 2015) 107.49 ± 0.00 , 107.49 ± 0.00 , $112.33 \pm 0.00^*$, 106.87 ± 0.00 .

Magnesium shows a significant ($p > 0.05$) increase when preserved with ash and decrease when preserved with pepper. Calcium contents showed a significant decrease when preserved with pepper in line with that reported by Asibuo *et al.*, (2008), 25.50 ± 0.00 , 24.57 ± 0.00 , 24.86 ± 0.00 , $21.51 \pm 0.00^*$. Calcium is very essential in blood clotting, muscle contraction and in certain enzyme metabolic processes. Calcium also contributes to strong bones and teeth.

Amino Acid content of soybeans

The amino acid content of soybean treated with birds eye pepper, ash and 0.2 ml of DDVP are shown in Table 2.

Table2. Effect of Dichlorvos (2, 2- Dichlorovinyl Dimethyl Phosphate), Pepper, and Neem-stem Ash on amino acid composition of Soybeans{mg/g}

AMINO ACID	CONTROL	DDVP	ASH	PEPPER
<u>Leucine</u>	7.79±0.00	7.00±0.00	7.41±0.00	6.30±0.00*
Lysine	6.37±0.00	5.83±0.00	6.10±0.00	4.35±0.00*
Isoleucine	4.62±0.00	3.93±0.00*	4.19±0.00	3.10±0.00*
Phenylalanine	4.70±0.00	3.99±0.00	4.26±0.00	3.55±0.00*
<u>Norleucine</u>	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
<u>Tryptophan</u>	1.31±0.00	0.97±0.00	1.05±0.00	0.68±0.00*
<u>Valine</u>	5.03±0.00	4.36±0.00	4.50±0.00	3.74±0.00*
Methionine	1.28±0.00	1.10±0.00	1.21±0.00	0.72±0.00*
<u>Proline</u>	5.38±0.00	4.48±0.00	5.28±0.00	4.26±0.00*
Arginine	7.74±0.00	7.35±0.00	7.57±0.00	6.37±0.00*
<u>Tyrosine</u>	3.10±0.00	2.75±0.00	3.10±0.00	2.41±0.00*
<u>Histidine</u>	2.97±0.00	2.75±0.00	2.43±0.00	1.92±0.00*
<u>Cystine</u>	1.27±0.00	1.21±0.00	1.21±0.00	0.85±0.00
Alanine	4.17±0.00	3.79±0.00	3.91±0.00	3.19±0.00*
Glutamic Acid	17.11±0.00	15.75±0.00	16.05±0.00	13.63±0.00*
Glycine	4.10±0.00	3.90±0.00	3.99±0.00	3.18±0.00*
Threonine	4.16±0.00	3.61±0.00	3.72±0.00	3.05±0.00*
Serine	5.00±0.00	4.48±0.00	4.70±0.00	3.40±0.00*
<u>Aspartic Acid</u>	11.41±0.00	10.30±0.00	11.01±0.00	8.99±0.00*

KEY: Mean±Standard Deviation. *(P< 0.05) are considered statistically significant
Control = No preservative. DDVP = 2, 2- DichlorovinylDimethyl Phosphate

The result of this research is similar to that reported by Wilcox and shibles (2001). There was a significant (P<0.05) decrease in amino acid concentration in samples preserved with pepper. The amino acid compositions in soya bean contributes to the growth and repair of worn out tissues and also improve the nutrition of humans and animals. Therefore preservation with pepper decreases the amino acid content of Soybean. There was also a significant decrease in the concentration of amino acid when preserved with dichlorvos but less so with Ash.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study has demonstrated that, the choice of preservatives greatly affects the nutrient content of the legume Soybeans. There is a significant ($P < 0.05$) change in the concentrations of nutrient content in Soybean after preservation using pepper, ash, and dichlorvos as compared to the control samples with no preservative. Significant decrease in amino acid composition, minerals and proximate content of the legume after preservation were observed. Samples, preserved with dichlorvos showed better statistical results as compared to pepper and ash, although it is currently considered harmful for preservation, due to the exposure at excess quantity can lead to neurological dysfunction and death in living organism.

Recommendation

It is recommended that careful consideration be taken when making a choice of preservative and organic preservatives should be used as alternatives for dichlorvos for safety purposes. It is suggested that the mechanism behind decreased nutrients while preserving with pepper and ash be subjected for further studies.

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EVALUATION OF MICRO-NUTRIENT COMPOSITION OF YOGHURT PRODUCED FROM BAMBARA NUT (*VIGNA SUBTERRANEAN*) AND TIGER NUT (*CYPERUS ESCULENTUS*)

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Abstract

This study investigated the micronutrient composition of yoghurt produced from Bambara nut (*Vigna subterranean*) and Tiger nut (*Cyperus esculentus*). From the result, the calcium content obtained from the samples indicated that the values ranged between 0.42% and 0.83%, bambara nut yoghurt rated highest (0.83%). Magnesium (mg) content ranged from 0.26 - 0.51% and bambara nut yoghurt were significantly ($P < 0.05$) highest of the three samples. The vitamin A content found in the three samples YA -Bambara nut and Tiger nut Yoghurt (9.96 %), Bambara nut yoghurt - YB rated (7.18%) and Tiger nut yoghurt -YC varied significantly ($P < 0.05$) and sample YB rated (7.18%). Bambara and tiger nuts yoghurt can make significant contributions to the human diet. Bambara nut; Tiger nut; Vitamin; Mineral; Yoghurt

Introduction

Yogurt is a worldwide popular product obtained by milk lactic acid fermentation through the action of yogurt starter culture. It is a healthy food because it contains a high amount of protein and calcium [1]. The optimal conditions of fermentation of Bambara groundnut milk using lactic acid bacteria was evaluated [2]. The study was designed to produce and determine the micronutrient composition of yoghurt from Bambara nut and tiger nut.

Materials and Methods

The tiger and Bambara nuts, peak powdered milk, and Lactobacillus spp. starter culture were all obtained from Cemetery Market Aba, Abia State, Nigeria. Bambara nut was sorted, washed, drained, and soaked for 24 hr. The skin was removed, then roasted, milled and strained to obtain the milk. Tiger nut was sorted, washed, drained, soaked for 24hr, washed with warm water, milled, and strained to obtain milk.

The micronutrient composition of samples was analyzed in triplicates using AOAC methods [3]. Data were analyzed in replicates one-way ANOVA at 0.05 level of significance [4].

Results and Discussion

The result in Table 1 shows the comparison of the mean mineral compositions of yoghurt processed from Bambara nut and Tiger nut yoghurts. The calcium content obtained from the samples indicated that the values ranged between 0.42% and 0.83%, YB (0.83%) rated highest. Magnesium (Mg) content ranged from 0.26-0.51% and YB was significantly ($P < 0.05$) highest of the three samples. Magnesium provides bone strength, aids enzyme, nerve and heart functions. Tiger nuts contain protective nutrients because it could supply adequate zinc, copper, iron, [5]. Sulphur (S) content ranged from 0.13- 0.23%, YA (0.23%) and YC (0.23%) did not vary significantly ($P > 0.05$) but both varied significantly ($P < 0.05$) from YB (0.13%). Lead (Pb), Chromium (Cr), Mercury (Hg), Arsenic (As) were present in minute quantities in the three samples.

The results obtained for vitamin compositions of the samples as shown in table 2 indicate that vitamin A content of sample YC (12.77%) was the highest, YB (7.18%), and the blend of the two sample YA (9.96 %). Thus vitamin A content of sample YA (9.96 %) showed a significant difference from the level of vitamin A found in samples YB (7.18%) and YC (12.77%). Vitamin B12 content in the samples ranged from 3.71 -9.34 % and vitamin C ranged from 9.14- 22.50%, overall the results in the table shows that sample YA has comparatively higher levels of vitamins B12 and C. Vitamin C is a powerful antioxidant which is important in the prevention of coronary diseases and cancer [5].

Conclusion

The results of the study showed that micronutrient compositions of yoghurt produced from Bambara nut and Tiger nut extracts and yoghurt produced from the combination of both Bambara and Tiger nut extracts can make significant contributions to human diet as well as support to alleviation of food security problems. Hence it is recommended that further studies be undertaken for possible exploitation of these products for food security and nutritional benefits.

TABLE 1: Mineral composition of Yoghurt Produced from Bambara Nut and Tiger Nut Extracts (YA); Bambara Nut Extract (YB); Tiger Nut Extract (YC) (% andPPM)

Sample	Ca (%)	Mg (%)	K (%)	P (%)	S (%)	Na(ppm)	Mn(ppm)	Fe(ppm)	Zn(ppm)	Cu(ppm)	Pb(ppm)	Cr (ppm)	Hg(ppm)	As (ppm)
YA	0.75±0.03	0.48±0.02	0.24±0.03	0.14±0.00	0.23±0.00	22.13±0.05	71.26±0.14	56.14±0.25	77.76±0.27	5.09±0.02	0.01±0.00	0.04±0.00	0.05±0.00	0.02±0.00
YB	0.83±0.00	0.51±0.05	0.32±0.02	0.08±0.00	0.13±0.00	21.54±0.04	69.32±0.34	70.91±14.3	79.25±0.34	7.92±0.02	0.04±0.00	0.03±0.00	0.03±0.00	0.05±0.00
YC	0.42±0.00	0.26±0.03	0.09±0.00	0.15±0.00	0.23±0.00	0.62±0.00	29.5±21.3	56.0±0.20	77.43±0.47	5.06±0.00	0.04±0.00	0.03±0.00	0.01±0.00	0.02±0.00

Values are means of three independent determinations ±SEM

Table 2: Vitamin compositions (%) of Yoghurt Produced from Bambara Nut and Tiger Nut Extracts (YA); Bambara Nut Extract (YB); Tiger Nut Extract (YC) (%)

Sample	Vit A	Vit B6	Vit B12	Vit C	Folate	Vit E	Vit K	Vit B1	Vit B2	Vit B3
YA	9.96±0.08	1.54±0.06	9.34±0.07	22.5±0.07	28.3±0.34	0.13±0.00	0.05±0.00	0.05±0.02	0.07±0.00	0.01±0.00
YB	7.18±0.03	2.65±0.06	9.08±0.03	21.7±0.09	27.08±0.02	0.16±0.00	0.16±0.00	0.06±0.03	0.08±0.00	0.03±0.00
YC	12.7±0.03	5.97±0.14	3.71±0.17	9.14±0.10	16.4±0.44	0.15±0.04	0.13±0.00	0.05±0.03	0.06±0.07	0.02±0.00

Values are means of three independent determinations ±SEM

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EVALUATION OF PROXIMATE COMPOSITION AND SENSORY PROPERTIES OF YOGHURT PRODUCED FROM BAMBARA NUT (*VIGNA SUBTERRANEAN*) AND TIGER NUT (*CYPERUSESCULENTUS*)

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Abstract

The production, proximate and sensory properties of Yoghurt were conducted. Matured bambara (*Vigna subterranean*) and tiger nuts (*Cyperus esculentus*) were obtained from the Cemetery Market Aba, Abia State, Nigeria. The proximate composition and sensory properties of the three samples were determined. The result of the yoghurt showed that the mixture of tiger and bambara nuts yoghurt had the highest contents in moisture (17.51%), and bambaranut yoghurt had the highest contents in protein (8.70 %) and fat (17.12 %). Tiger nut yoghurt had the least contents in protein (6.79 %) and ash (9.20 %). The sensory properties showed that the tiger nut yoghurt rated highest in Appearance (7.52), Aroma (6.68), Taste (8.44), Texture (8.40), and the overall acceptability (7.53). Bambara /tiger nut yoghurt can nutritionally substitute cow milk yoghurt.

Introduction

The consumption of yoghurt in Nigeria has increased tremendously so much so that lots of beverage industries are producing it in commercial quantities for millions of the populace who have embraced this fermented food product as part of their daily diet. Yoghurt, a fermented milk product consumed by large segments of the population either as a part of the diet or as a refreshing beverage is one of the oldest fermented milk products known. Human consumption of yoghurt has been associated with tremendous health benefits due to improvement of gastrointestinal functions and disease risk reduction following its daily consumption (Ezeonu *et al.*, 2016). The objective of this study was to investigate the proximate composition and organoleptic properties.

Materials and methods

The tiger and Bambara nuts, powdered milk, and starter culture were all obtained from Cemetery Market Aba, Abia State, Nigeria.

Bambara nut was sorted, washed, drained, and soaked for 24 hr. the skin was removed, then roasted, milled, and strained to obtain the milk. Tiger nut was sorted, washed, drained, soaked for 24hr, washed with warm water, milled, and strained to obtain milk.

The proximate composition (moisture, ash, fat, lipid, crude protein, crude fibre and carbohydrate contents) of samples were analyzed in triplicates using AOAC methods (AOAC, 2010). The 9-Hedonic scale was used for the organoleptic properties yoghurt samples Iwe, 2012. Data were analyzed in replicates in replicates one-way ANOVA at 0.05 level of significance Landau & Everitt (2017) .

Results and Discussion

The result Table1 shows the proximate composition of the yoghurt processed from Bambara nut and Tiger nut yoghurt. The three samples differed significantly ($P < 0.05$). The protein content of samples ranged from 6.79 to 8.70 %, and sample YC (6.79 %) was rated lowest. The moisture content of the three samples varied significantly ($P < 0.05$) and the samples rated thus; YA (17.51 %), YB (16.73 %) and YC (12.53 %). The carbohydrate content in the three samples YA (24.15 %), YB rated (24.22 %) and YC (38.36 %) varied significantly ($P < 0.05$).

Table 2 shows the sensory properties of yoghurt processed from Bambara and tiger nuts. The yoghurt samples varied significantly ($P < 0.05$) with the values of YA (5.52), YB (6.32), YC (6.68) for aroma. Sample YC (7.52) rated highest among the three samples, followed by sample YB (6.92) and the least

was YA (5.80). In terms of overall acceptability, the sample YC (7.53) was highly accepted and rated highest while sample YB (6.93) was rated second and YA (5.81) had least the value.

Conclusion

This study found that the combined Bambara and tiger nut yoghurt produced can be a close substitute for cow milk yoghurt since the product contains the desired nutrients, as evidenced by the analytical results. As a result, this product (Bambara /tiger nut yoghurt) can nutritionally substitute cow milk yoghurt. Furthermore, yoghurt made from plant sources is less expensive than yoghurt made from animal sources, which vegetarians would appreciate.

TABLE 1: Proximate Composition of Yoghurt Produced with Bambara Nut and Tiger nut (%)

Sample	Protein	Moisture	Ash	Crude Fiber	Fat	Carbohydrate
YA	8.010 $\pm$ 0.16	17.51 $\pm$ 0.18	12.60 $\pm$ 0.12	19.89 $\pm$ 0.21	15.24 $\pm$ 0.06	24.15 $\pm$ 3.40
YB	8.70 $\pm$ 0.16	16.73 $\pm$ 0.48	11.13 $\pm$ 0.14	15.38 $\pm$ 10.89	17.12 $\pm$ 0.07	24.22 $\pm$ 0.08
YC	6.79 $\pm$ 0.14	12.53 $\pm$ 0.07	9.20 $\pm$ 0.15	20.80 $\pm$ 0.22	12.30 $\pm$ 0.22	38.36 $\pm$ 0.58

Table 2: Mean Sensory evaluation of Yoghurt from Bambara/ Tiger nuts

Sample	Appearance	Aroma	Taste	Texture	Overall Acceptability
YA	5.80 $\pm$ 0.29 ^a	5.52 $\pm$ 0.27 ^a	8.08 $\pm$ 0.40 ^b	7.72 $\pm$ 0.38 ^{ab}	5.81 $\pm$ 0.29 ^b
YB	6.92 $\pm$ 0.34 ^a	6.32 $\pm$ 0.31 ^a	8.24 $\pm$ 0.41 ^a	7.32 $\pm$ 0.36 ^a	6.93 $\pm$ 0.34 ^a
YC	7.52 $\pm$ 0.37 ^a	6.68 $\pm$ 0.03 ^a	8.44 $\pm$ 0.42 ^{ab}	8.40 $\pm$ 0.40 ^b	7.53 $\pm$ 0.37 ^{ab}
LSD	N.S	N.S	1.72	0.72	1.75

Values are mean $\pm$ S.D of the triplicate determination and LSD. Mean differently superscripted along the vertical columns are significantly different (P<0.05).

YA - Bambara nut and Tiger nut Yoghurt

YB - Bambara nut Yoghurt

YC - Tiger nut Yoghurt

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PROXIMATE COMPOSITION OF YELLOW TIGER NUT SEEDS AND TIGERNUT MILK PROCESSED USING DIFFERENT METHODS.

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ABSTRACT

Tigernut (*Cyperus esculentus*) is an underutilized tuber of the family *Cyperaceae*, which produces rhizomes from the base of the tuber that is somewhat spherical. In this study, it was processed into varieties of substitute milk products like soaked malted tigernut milk, sterilized yellow tigernut milk, soaked fresh tigernut milk, soaked sterilised tigernut milk and boiled tigernut milk and boiled and sterilised tigernut milk. The moisture contents increased from the raw tigernut seeds (39.25%) to values not less than 89.84% in all the milk samples. The crude fibre content in the Tigernut seeds (11.54%) reduced to 0% in all the milk samples. Apart from the moisture contents, all other proximate contents were adversely affected by processing.

Key Words: Tigernut milk, Fresh, Sterilised, Boiled, Proximate Composition

INTRODUCTION

Tigernut (*Cyperus esculentus*) is an underutilized tuber of the family *Cyperaceae*, which produces rhizomes from the base of the tuber that is somewhat spherical (Devries and Feuke, 1999). It is a tuber that grows freely and consumed widely in Nigeria and other parts of West Africa, East Africa, parts of Europe particularly Spain as well as in the Arabian peninsula (Abaejoh *et al.*, 2006). In Nigeria, Tigernut is known as *Aya* in Hausa, *Ofio* in Yoruba and *Akianusa* in Igbo. The main objective of this study was to investigate and improve the commercial value of Tigernut milk as an industrial raw material for food formulation. Three varieties (black, brown and yellow) are cultivated in Nigeria and among these, only two varieties (yellow and brown) are readily available in the market. The yellow variety is preferred to all other varieties because of its inherent properties like its bigger size and attractive colour. The yellow variety also yields

more milk, more protein, contains lower fat and possess less anti-nutritional factors especially polyphenols (Okaforet *et al.*, 2005). Tigernut tubers can be eaten raw, dried, roasted, prepared as tiger nut milk or oil, used in the production of biscuits, bread and other bakery products (particularly as a composite), used in making jams, beer and as a flavouring agent in ice cream. Tigernut milk originated from Spain where it is known as *Chufa de horchata*. It is called *kunnuqayin* Northern Nigeria. It is a very nutritive energy drink for both young and old. The qualities of Tigernut in this context makes its inclusion in the preparation of beverage desirable so as to provide protein energy-rich drink at affordable price in places where animal protein/fat is scarce and expensive (Nsofor and Osuji, 1997). It can be processed into varieties of substitute milk products like ordinary Tigernut milk, pasteurized Tigernut milk, sterilized Tigernut milk, ultra-high temperature Tigernut milk and concentrated and condensed Tigernut milk and other variants. It is a healthy and rich source of nutrients such as carbohydrates, vegetable fat, protein, fibre, vitamins, minerals, energy and some digestive enzymes such as catalase, lipase and amylase (Arnau, 2009). Tigernut milk has been reported to contain more iron, magnesium and carbohydrate than cow milk (Belewu and Abodunrin, 2006). It has the advantage of not containing sodium, lactose sugar, casein protein, gluten and cholesterol which makes it ideal for people who are hypertensive or intolerant to gluten or lactose and its derivatives in cow milk (Anon, 2005). Unlike soymilk or other soy products, tigernut milk does not produce any allergy (Anon, 2012).

MATERIALS AND METHODS

Tigernut milk preparation

Fresh tigernuts were used for the preparation of Tigernut extract/milk. Fresh Tigernuts were visually inspected for defective tubers were manually removed and discarded. Hence, only matured healthy Tigernut tubers were selected. Tigernuts were weighed out in portions washed thoroughly in two changes of clean water and drained prior to use for all the studies. The Tigernut tubers were processed using different methods before extraction of the milk.

Boiling method

Boiled Tigernuts milk were prepared using the method of Ndubuisi(2009). Fresh Tigernuts (200g) were boiled at 100°C for 5minutes until tuber became soft for easy extraction. The boiled Tigernuts were ground using Omini blend V model TM 800 into paste. A 500 ml portion of distilled water was used all together during the blending and slurring process. The slurry was filtered with the aid of a clean damp muslin cloth and the filtrate obtained was boiled at 70°C for 15minutes to avoid curdling before bottling and capping for further studies.

Malting method

The malted Tigernutsmilk samples were prepared using the method of Ndubuisi (2009).A portion of fresh Tiger-nut 200g was soaked in a vessel for 24 hours and was drained out. The soaked Tiger-nuts were washed, drained and put in a jute bag at room temperature. Water was sprinkled twice a day to soften the tubers. After 5 days, it germinated bringing out shoots and roots. After the sprouting period, the Tiger-nut tubers were cleaned, washed, drained and blended into a slurry in an electric blender. 500ml of water was used during the blending process. The slurry was filtered with the aid of a clean muslin cloth and the filtrate obtained

was boiled at 70°C for 15 minutes to avoid curdling before bottling and capping for further studies.

The samples were sterilised at 121°C for 10 min using the modified method of Ukwuru and Ogbodo (2011).

The package was sterilized at 130°C for 10s and cooled before storage under refrigerated condition (Ukwuru and Ogbodo, 2011).

Proximate analysis

The moisture, protein and ash content of the tigernut milk samples was determined using standard analytical methods (Onwuka, 2018). Moisture was determined by using an automatic moisture analyser (AND ML-50, Japan). Ash content was determined gravimetrically in a muffle furnace (Sanyo Gallenkamp, Weiss Technik, West Midlands, UK) at 500°C for 24 hours. Determination of protein was by Kjeldahl method. After distillation and titration, the nitrogen was converted to protein using a factor of 5.7. Fat was determined by Rose-Gottlieb method (Onwuka, 2018). Carbohydrate was obtained by difference.

Statistical Analysis

Data obtained were subjected to descriptive statistics and means subjected to one-way analysis of variance (ANOVA). Means, where significantly different at $p < 0.05$ were separated using Duncan's Multiple Range Test (DMRT) with Statistical Package for the Social Science Version 21.0.

RESULTS AND DISCUSSION

The results of the proximate composition are presented in Table 1.

Table 1: Proximate Composition (%) of Tigernut seeds and milk samples

Tigernut seeds/milk Samples	Moisture	Ash	Fat	Crude Fibre	Protein	Carbohydrate
Malted yellow & fresh milk	91.83 ^b ±0.33	0.28 ^b ±0.01	5.69 ^c ±0.11	0.00 ^b ±0.00	0.28 ^{de} ±0.01	1.93 ^d ±0.23
Malted Yellow Sterilised milk	89.90 ^c ±0.48	0.25 ^c ±0.01	5.13 ^d ±0.06	0.00 ^b ±0.00	0.26 ^e ±0.01	4.44 ^b ±0.42
Soaked Yellow Fresh milk	92.90 ^a ±0.21	0.20 ^d ±0.00	6.53 ^b ±0.21	0.00 ^b ±0.00	0.34 ^b ±0.01	0.04 ^e ±0.00
Soaked Yellow Sterilised milk	93.05 ^a ±0.04	0.16 ^{ef} ±0.01	6.15 ^{bc} ±0.06	0.00 ^b ±0.00	0.30 ^c ±0.01	0.35 ^e ±0.03
Boiled Yellow Fresh milk	89.84 ^c ±0.29	0.18 ^d ±0.02	6.20 ^{bc} ±0.04	0.00 ^b ±0.00	0.33 ^b ±0.01	3.47 ^c ±0.28
Boiled Yellow Sterilised milk	93.19 ^a ±0.01	0.14 ^f ±0.01	6.13 ^{bc} ±0.01	0.00 ^b ±0.00	0.29 ^{cd} ±0.01	0.26 ^e ±0.02

Raw Yellow seeds	39.16 ^d ±0.13	1.51 ^a ±0.01	22.49 ^a ±0.52	0.00 ^b ±11.52	1.74 ^a ±0.01	23.57 ^a ±0.06

Key: Means with different superscripts in the same column are significantly ($P \leq 0.05$) different.

Tiger nut seeds had the lowest moisture content at 39.16% is the raw Tiger nut seeds. Due to the processing methods used in preparing the milk, the moisture contents of the tiger nut milk varied from 93.19% (boiled sterilised) to 89.84% (in the boiled samples). The soaked samples both the fresh and the sterilised Tiger nut milk had the highest moisture contents, probably due to the water imbibed during the soaking process. The ash content was also highest in the tiger nut seeds. From the lower ash content values (0.14 -0.28%) obtained, it is likely that some of the mineral contents were lost with the husks during processing. Amongst all the processed samples, the malted tiger nut milk seemed to retain the highest ash content. Thus its mineral content is expected to be higher than in the sterilised, boiled, and soaked samples. There was a substantial loss of fat from the raw (22.49%) tiger nuts compared to the milk samples, where the highest fat content (6.53%) was recorded is the soaked tiger nut milk samples. The fat contents may be harnessed from the germs embedded in the chaff. The carbohydrate contents of the malted milk samples (4.44%) is the highest amongst all the processed milk samples. As expected, no fibre content was recorded in the milk samples. The milk samples are low in protein contents. The highest benefit from the tiger nut milk samples is that it is refreshing and dairy free.

Conclusion

This study showed that apart from the moisture contents that increased due to the processing of the tiger nut seeds into milk, samples, all other nutritional parameters analysed decreased in the milk samples. Processing of tiger nuts into milk irrespective of the processing methods adversely affected the proximate composition of the milk.

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DEVELOPMENT AND ACCEPTABILITY OF A SOYMILK BEVERAGE FROM AN INTERMEDIATE SOYBEAN PRODUCT

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Abstract

Soy milk has become important in the dietary pattern of people in most developing countries. However traditional production of soy milk over the years involves a wet milling procedure which makes it cumbersome and leads to a product of short shelf life. This work is an attempt to produce a soy milk beverage using an intermediate soybean product devoid of the wet-milling process. Soybeans (*Glycine-max*) were first processed into an intermediate soybean product by dry milling into powder, a sample of sorted, washed, stepped and parboiled soybean grains. The intermediate soybean product was then subsequently processed into a soy milk beverage by rehydrating in portable water for 3 hours; filtering and pasteurizing the milky extract. The extract was flavored and sensory evaluated for its appearance, color, consistency, aroma, test and overall acceptability in comparison with a traditionally process soy milk sample and a commercial sample used as the controls. Results obtained shows that there were no significant differences (at $p \leq 0.05$) among the three soy milk samples in all the sensory parameter evaluated. This work therefore suggests that a soy milk beverage of acceptable quality can be produced from an intermediate soybean product without passing through the traditional wet milling process.

KEYWORDS:

Soy milk, Product Development, Intermediate Soybean Product, Traditional Processing Method, Acceptability.

Introduction

Several milk and milk- like products from legumes have been developed in an attempt to increase the supply of milk-like products especially in areas where milk is in short supply. Legumes are important sources of relatively inexpensive protein and the production of imitation milk products from legumes has been contributing to the alleviation of protein malnutrition (Ciabotti et al.,2006). Soy milk, a popular beverage from soybean has been reported to be the most popular of these products in Nigeria because of its refreshing and nutritious nature (Gesinde et al.,2008).

Soy milk is an aqueous, white, creamy extract produced from soybeans which resembles cow milk both in appearance and consistency (Gesinde et al.,2008).(Ishiwu et al.,2014). It is a highly nutritious food drink which contains protein, fat, carbohydrates, vitamins and minerals. It is because of its nutritious value and comparative low cost, that soy milk as become important in the dietary pattern of people in most developing countries (Mbajiuka et al., 2014). Recently,

the consumption of soymilk has greatly increased for reasons which include poverty alleviation and because it is recommended for people that cannot tolerate lactose since it does not contain lactose. It is continuously being used as a substitute for cow milk in most remote areas of Nigeria and indeed Africa (Momoh et al., 2011). Traditionally, soymilk is produced by wet milling the sorted soybeans which has been previously steeped and per-boiled in hot water, straining out the milky extract which is then pasteurized and flavored. This process of wet milling soybeans, usually carried out by the road side operators is unhygienic and cumbersome because of environmental contamination which may be introduced in the process. Besides, this traditional practice of producing soymilk using wet milling procedure often results to a product of short shelf life.

Developing a new product is part of the growth of the food industry. The food industry cannot always rely on the traditional method of generating existing product if it is to meet the demands of the growing population. It is important that new products should be advanced and innovations be made to give room for improvement

The term intermediate product can be described as partly processed consumer goods, convenient for storage and for further processing into other end products whenever desired. Considering the importance of soymilk as a good source of protein in the diet of low income population in a developing country like Nigeria, there is a need to develop an innovation in the production of soymilk by preparing it from an intermediate soybean product which would make it convent for both small and large scale processing without the cumbersomeness of a wet milling process. But such an innovation should be one that would result in a product of similar nutritious quality and acceptability like the traditionally produced soymilk.

The aim of this work therefore is to develop and evaluate the acceptability of a soymilk beverage made from an intermediate soybean product using simple technology

Materials and Method

Sourcing and Pretreatment of Raw Materials

Wholesome grains of soybean (*Glycine-max*) were purchase from Eke market Afikpo in Afikpo North Local Government of Ebonyi State. The grains were sorted, washed with portable water, and then steeped for 10 hours with 5 times their equal weight of water; the steeped soybeans were drained, rinsed and then par-boiled for about 20 minutes.

Processing of Soybean Grains into an Intermediate Soybean Product

The par-boiled soybeans were divided into 2 equal portions. The first portion was subjected to drying in a cabinet dryer at 70°C. The drying was continued until the grains became friable such that the hulls could easily come off. The dried grains were then taken to a dry milling unit for simultaneous dehulling and dry milling into powder using a disc mill. The powdered soybean product was then sieved to remove coarse particles through a 100 mesh sieve. The resulting powdered product was packaged as an intermediate soybean product for used in the production of soymilk beverage.

Production of Soymilk from the intermediate Soybean Product

Soymilk was obtained from the intermediate soybean product by steeping 1 part of the intermediate soybean product with 5 parts of potable water in a big glass jar, stirred and left to rehydrate at room temperature for 3 hours.

The steeped sample was then filtered through a double folded muslin cloth and the milky extract collected directly into a stainless steel pot. Granulated sugar 8.0% by weight of the milky extract was added and the milky extract was then pasteurized at 65°C for 30 minutes with constant stirring. The pasteurized soymilk sample was then cooled to room temperature, packaged, labeled and then refrigerated for further analysis.

Production of Soymilk using the Traditional Method

The second portion of the steeped parboiled soybean was processed into a soymilk beverage using the traditional method as described by (Mbajuka et al., 2014). The steeped par-boiled soybean samples were rubbed and rinsed in portable water to separate the hulls and then wet milled into slurry using a disc mill. The slurry was mixed with 5 portions of its weight in portable water and then filtered through a double folded muslin cloth to obtain the milky extract. Granulated sugar, 8.0% by weight of the milky extract was added and the extract was pasteurized at 65°C for 30 minutes with constant stirring. The pasteurized soymilk was allowed to cool to room temperature, packaged, labeled and refrigerated for further analysis.

Sensory Evaluation of Soymilk Samples

The 2 soymilk samples obtained from the intermediate soybean product and the Traditionally processed method were subjected to sensory evaluation using a 20-man sensory panelist and a commercial soymilk sample (vita milk) as the control. The soymilk samples were evaluated for their organoleptic acceptance in terms of their appearance, color, consistency, aroma, taste and overall acceptability. A 9-point hedonic scale was used for their sensory parameters whereby: 9= Extremely liked, 8= Mostly liked, 7= Moderately liked, 6= Liked, 5= Neither like nor dislike, 4= Dislike, 3= Moderately dislike, 2= Mostly dislike, 1= Extremely disliked.

Data generated were statistically analyzed using the Analysis of Variance. Mean values were subjected to one way analysis of variance (ANOVA) at 5% level of significance using SPSS 17.0 software for windows. Means were separated using Duncan's multiple range tests.

Results and Discussion

Table 1: Mean Sensory Scores on Soymilk Samples

Sample	Appearance	Color	Consistency	Aroma	Taste	Overall
Acceptability						
TPS		6.50 ^a ±0.05	6.50 ^a ±0.01	7.10 ^a ±0.05	6.40 ^a ±0.08	6.90 ^a ±0.01
MPS	6.70 ^a ±0.02	6.50 ^a ±0.02	6.80 ^a ±0.03	6.70 ^a ±0.09	6.80 ^a ±0.03	6.80 ^a ±0.01
CSS	6.30 ^a ±0.07	6.40 ^a ±0.03	7.20 ^a ±0.04	6.50 ^a ±0.04	6.50 ^a ±0.04	6.60 ^a ±0.03

Mean scores with same superscript in the same column are not statically different from each other (at p ≤ 0.05)

KEY:

TPS = traditionally processed soymilk

MPS = Soymilk processed from an intermediate soybean product

CSS = Commercial soymilk samples

Sensory evaluation is a vital aspect of food product development. It is used to ascertain consumer's acceptability of the product. The mean sensory scores of the soymilk samples are shown in Table 1 above. It could be seen that there were no significant differences (at $p \leq 0.05$) between the two soymilk samples differently prepared and the commercial samples used as control in all the sensory parameters evaluated.

It is interesting to note that the soymilk samples produced from the intermediate soybean product (MPS) scored above 6 points which shows a good acceptability.

Conclusion

It could be seen that a soymilk beverage traditionally produced using the wet milling process as well as a commercial soymilk sample used as the control were both not significantly different (at $p \leq 0.05$) from the soymilk sample obtained from the intermediate soybean product in all the sensory parameters evaluated. This work therefore demonstrated that an acceptable soymilk beverage can be developed from an intermediate soybean product.

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MINERALS AND VITAMINS CONTENT OF RESIDUES FROM TWO VARIETIES OF TIGERNUT (*CYPERUS ESCULENTUS* L.)

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Abstract

Tigernut processing generates nutritionally valuable residue (about 60% of raw material) that contribute to environmental pollution. This research determined the minerals and vitamin content of tigernut residue with the aim of utilizing it in food production. Tigernuts (yellow and brown variety) were sorted, washed, dried, soaked, wet-milled, sieved, and the residue dried. The minerals and vitamin content were determined using standard methods. Yellow tigernut residue (YTRF) has higher content of iron (2.86 mg/ 100g), potassium (468 mg/ 100g), manganese (2.29 mg/ 100g) and Magnesium (206 mg/ 100g) compared to Brown tigernut residue flour (BTRF) with higher content of phosphorus (109 mg/ 100g) and calcium (306 mg/ 100g). Vitamins B2 (0.923 mg/ 100g), B3 (0.097 mg/ 100g) and B6 (0.623 mg/100g) are higher in YTRF than in BTRF. The micronutrients content suggests that tigernut residue flours can be used to improve the nutritional composition of foods.

Keywords: Tigernut, Residue, minerals, vitamins, micronutrients

Introduction

Tigernut (*Cyperus esculentus* L.) is a pseudo nut belonging to Cyperaceae family. Tigernut is a rich source of oil and starch (Builders *et al.*, 2014). Although low in protein, tigernut is rich in the essential amino acids lysine, leucine, and isoleucine (Glewet *et al.*, 2006). Tigernut is usually consumed raw, dried, or roasted. It is usually processed into a milky drink, and starch (Builders *et al.*, 2014). Previous research showed that broilers fed with partially substituted tigernut meal diet displayed better growth (Archibong *et al.*, 2018).

Tigernut processing into milky drink generates about 60% residue (waste) used for feeding animals or discarded into the environment thereby constitute environmental pollution. Sanchez-Zapata *et al.*, (2010) stated that tigernut residue is rich in dietary fibre that can be used to improve human nutrition. However, information is scanty on the minerals and vitamin content of the residue. This research determined the minerals and vitamin content of tigernut residues with the aim of incorporating the residues in food formulation.

Materials and Methods

Tigernut (yellow and brown variety) were obtained from a local market in New Bussa, Niger State. The seeds were sorted to remove stones, pebbles, broken seeds and other dirt. The sorted seeds were washed with potable water, dried in the oven at 60 °C for 12 h, and soaked in sodium metabisulphite solution. The soaking solution was replaced after 24 h. After 48 h, the tigernut was wet-milled and sieved with a muslin cloth. The residue was air-dried for 12 h at room temperature (35 ± 2° C) before drying in the oven at 60 °C for 12 h. The samples were stored at -20 °C until analysed. Yellow and brown tigernuts residue flours were tagged YTRF and BTRF respectively.

Mineral elements were determined following the method described by Shahidi *et al* (1999) with minor modifications. Approximately 2 g of each sample was ashed for 2 h and dissolved in 5 ml of HNO₃ /HCL/H₂O (1:2:3, v/v/v) solution. It was heated on hot plate till disappearance of brown fumes and then filtered using Whatman No.1 filter paper into 100 ml volumetric

flask. This was filled to the mark and used for mineral analyses using Atomic Absorption Spectrophotometer (AAS). The standards, blank and sample solutions were read on AAS at the following wavelengths: 248.3 nm for iron, 213.9 for zinc, 422.7 nm for calcium, 285.2 nm for magnesium and 766.5 nm for potassium. For determination of vitamins, samples were extracted with either ethanolic sodium hydroxide, hydrochloric acid or sulphuric acid before the absorbance was read in a spectrophotometer at different wavelengths (vit B1 – 360 nm, vit B2 and B3 – 470 nm, vit E – 520 nm).

Statistical analysis

The results obtained were subjected to independent T-test using SPSS (version 20.0) software. Significant difference was obtained at $p < 0.05$

Results and discussion

The minerals and their concentrations in the tigernut residue flours are presented in Table 1. The concentration of the mineral elements in YTRF was in the order $K > Ca > Mg > P > Fe > Mn > Cu > Zn$ while it differs in BTRF with $Ca > K > Mg > P > Cu > Fe > Mn > Zn$. YTRF had significantly ($p < 0.05$) higher concentration of iron, potassium, manganese, and magnesium compared to BTRF which is significantly higher in phosphorus and calcium. However, YTRF and BTRF are not significantly ($p > 0.05$) different in Cu and Zn content. Zn had the least concentration in the two samples. The two residue flours are relatively high in potassium, phosphorus, calcium, and magnesium. Sodium was not determined due to the preservative (sodium metabisulphite) used during processing. It is believed that this could influence the result therefore give false result. The residue flours are not significantly ($p > 0.05$) different in vitamins B1 and E content. YTRF had significantly higher ($P < 0.05$) concentration of Vitamins B2, B3 and B6 compared to BTRF which is significantly higher in vitamin A.

Table 1: Minerals content (mg/100 g flour) of yellow and brown tiger nut residue flours.

Micronutrient	YTRF (mg/100 g)	BTRF (mg/100 g)
Iron	2.86 ± 0.64^a	1.41 ± 0.03^b
Potassium	468.33 ± 9.12^a	266.20 ± 10.98^b
Phosphorus	105.00 ± 0.00^b	109.33 ± 1.15^a
Zinc	0.02 ± 0.01^a	0.02 ± 0.01^a
Copper	1.43 ± 0.03^a	1.42 ± 0.01^a
Manganese	2.29 ± 0.03^a	1.39 ± 0.03^b
Calcium	301.70 ± 0.35^b	306.87 ± 0.98^a
Magnesium (mg/100 g)	206.11 ± 0.01^a	180.61 ± 0.00^b

YTRF: Yellow tiger nut residue flour, BTRF: Brown tiger nut residue flour. Values are means and standard deviations of triplicate determination. Values with the same superscript across the row are not significantly ($p > 0.05$) different

The mineral elements measured in the residue flours have been reported in tigernut (Glew *et al.*, 2006) and tigernut residue flour (Wayah and Shehu, 2015). The values obtained for the mineral elements are higher (except for iron and zinc) than the values reported by Wayah and Shehu (2015). Tigernut residue flours contain mineral elements that are germane to human growth, body function and development. Iron is required for blood formation, immune cells generation, function, and preservation. Calcium helps in bone and teeth development, activates enzymes, and helps in nerve regulation and muscle function. Potassium is a component of intracellular fluid, regulates osmotic pressure, aids nerve impulse and muscle contraction. It also aid cell membrane function (Soetan *et al.*, 2010). Zinc is an integral part of

hormones and is important in many metabolic reactions including alcohol metabolism, sexual development, and reproduction. The high concentration of the mineral elements suggests that tigernut residue can supply the required minerals for both children and adults if incorporated in food.

Table 2: Vitamin content (mg/ 100 g) of yellow and brown tiger nut residue flours.

Vitamin	YTRF (mg/ 100 g)	BTRF (mg/ 100 g)
Vitamin A	0.453±0.01b	0.663±0.01a
Vitamin B1	0.330±0.02a	0.310±0.01a
Vitamin B2	0.923±0.01a	0.910±0.00b
Vitamin B3	0.097±0.01a	0.070±0.00b
Vitamin B6	0.623±0.06a	0.053±0.01b
Vitamin E	0.093±0.02a	0.093±0.01a

YTRF: Yellow tiger nut residue flour, BTRF: Brown tiger nut residue flour. Values are means and standard deviations of triplicate determination. Values with the same superscript across the row are not significantly ($p > 0.05$) different

The vitamin content of the tigernut residue flours is shown in Table 2. Vitamins are organic compounds required in limited amounts for normal body growth and metabolism. Their deficiencies could lead to night blindness, dry skin, swollen joints, hair loss, bleeding gums, poor blood clotting and poor wound healing. The vitamin A content of the residue flours (0.45 and 0.66 mg/ g) compares favourably with 0.51 mg/ g reported by Wayah and Shehu (2015) for tigernut residue flour. However, the vitamins B1, B2, and E are lower compared to the values by the same authors. The difference in the values could be attributed to the source of material and methods of preparation. Although, tigernut residue flours have low vitamin content, they can contribute to the micronutrient content if incorporated in food.

Conclusion

Tigernut residue flours contain an appreciable quantity of minerals and vitamins required by human for normal functioning of the body. The residue flours can contribute to the micronutrient composition if incorporated in foods.

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PROXIMATE AND MINERAL COMPOSITION OF MAIZE MASA ENRICHED WITH SOYBEANS AND DRIED CATFISH

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Abstract

Masa is a traditional fried Cereal product which is round or spherical in shape with brown smooth body, it is popularly consumed in the Northern regions of Nigeria. This study was carried to evaluate proximate and mineral properties of maize -masa, enriched with soybean and dried catfish flour. The enriched maize-masa produced were labeled sample A (100% maize), sample B (maize: soybean: catfish 70:20:10% proportion respectively) sample C (maize: soybean: catfish 70:10:20% proportion respectively) sample D (maize: soybean: catfish 80:10:10% proportion respectively) sample E (maize: soybean: catfish 70:15:15% proportion respectively). The proximate and mineral composition was evaluated according to standard methods. Results from this study showed that the Carbohydrate content ranged from 64.71-83.53%, the Protein ranged from 7.61-23.62%, the fat from 2.58-5.74%, the Ash content ranged from 0.73-2.04%, the Moisture content ranged from 3.71-6.01%, the Fibre content ranged from 0.70-1.84%. The chemical analysis shows a significant ($p < 0.05$) difference in mineral content with sample B having the highest in iron, calcium and while sample C have the highest in phosphorus and with potassium content of 5.39mg/100g which is highest in sample E.

Key words: Masa; Proximate; Minerals, maize, catfish, soybean

Introduction

There are lots of food products and by products from cereals, consumed in Africa, but studies have shown that most of these cereals are low in protein. Masa is among the common foods that are low in protein; this demands effort to uplift its nutritional qualities. Masa can be produced from maize (*Zea mays*), millet (*Pennisetum typhoides*), sorghum (*Sorghum vulgare*) and rice (*Oryza sativa*) (Sanni and Adesulu, 2013). It is consumed in various forms by groups and tribes mostly in the Northern Nigeria and many other African countries (Mali, Burkina Faso, Niger, Chad and Ghana). It is principal ingredient of a variety of cereal-based foods and is a good source of income for the housewives who prepare the traditional product for sale. Masa serves as snacks or as a breakfast meal cake for many (Nkama *et al.*, 2003).

Soybean (*Glycine max*) is a leguminous vegetable of the pea family that grows in tropical, subtropical, and temperate climates. Soybean consists of more than 36% protein, 30% carbohydrates, and excellent amounts of dietary fiber, vitamins, and minerals. It also consists of 20% oil, which makes it the most important crop for producing edible oil (Edema and Sanni 2005), (Gibson and Benson, 2005).

African catfish (*Clarias gariepinus*) of the family Clariidae, is a moderately fatty fish that is also a good source of high-quality fish protein that occur in high concentration and possess an excellent amino acid balance. According to (Eyo, 2001). In addition to low in calories and sodium, catfish is packed with protein, healthy fats, vitamins and minerals. It is generally considered to be one of the most important tropical catfish species for aquaculture. (Anoop *et al.*, 2009). Maize, soybeans and Catfish combination was used by this study to expose Proximate and mineral properties of maize-masa.

MATERIALS AND METHOD

White Maize (*Zea mays*), Catfish (*Clarias gariepinus*), Yeast (*Sacharomyces cerevisiae*), Soybean (*Glycine max*) vegetable oil and salt were purchased at Central Market, Katsina, Katsina State.

Masa was produced using the modified method of Malomo and Abiose (2019) shown in figure 1

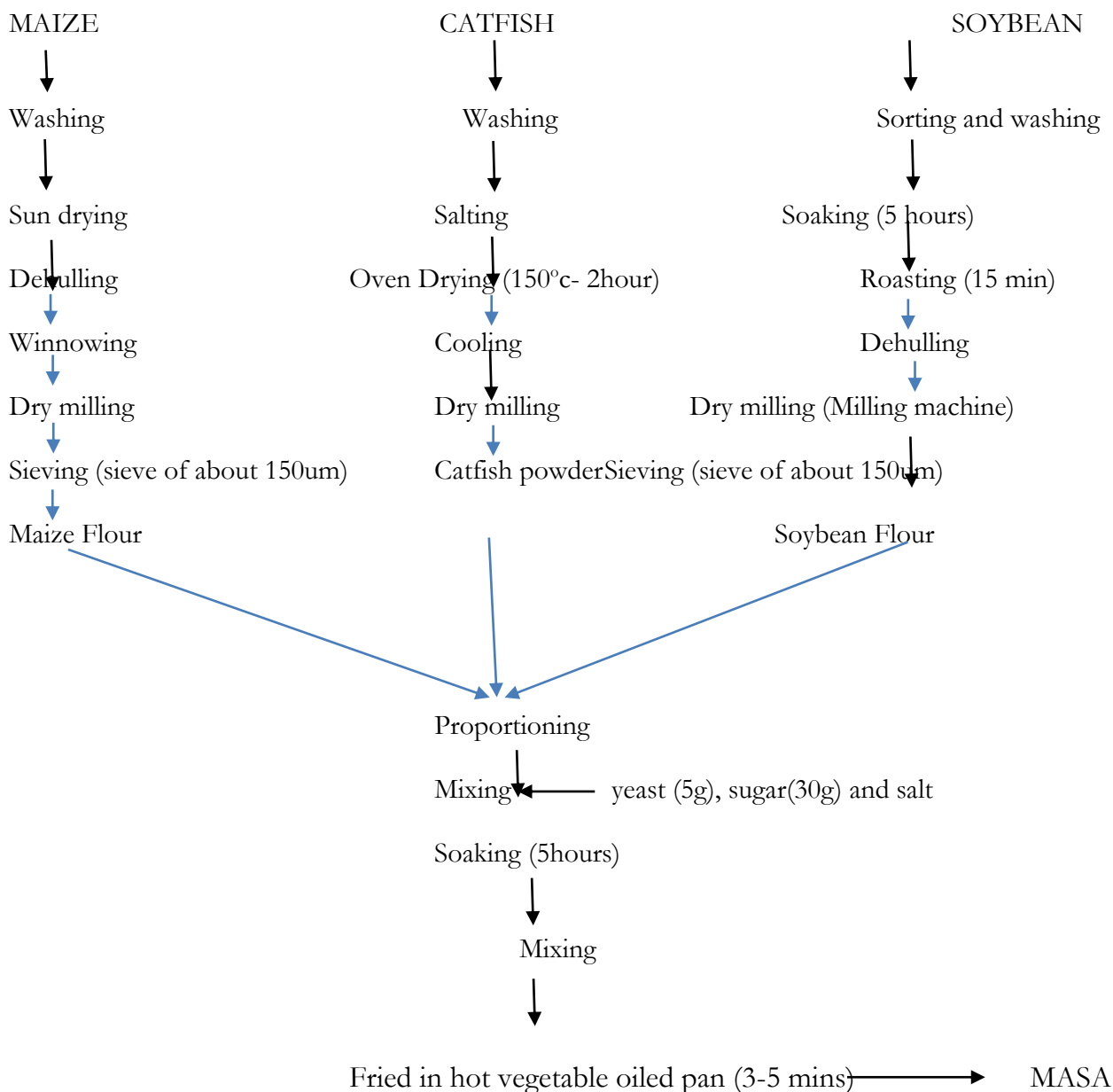


Figure 1: Production of masa

Source: Malomo and Abiose (2019) with modifications

Chemical Analysis of the Masa

Proximate analysis (Moisture, Ash, Protein, Crude fiber, and fat) of maize flour and the blend was determined by the official method of AOAC 2012. Carbohydrate by difference (100- the sum of content of protein, fat, ash and moisture).

Determination of Mineral Content

Calcium (Ca) level was determined using Atomic Absorption Spectrophotometer (210 VGP model). Sodium (Na) and Potassium (K) levels was determined using Flame Photometric Method while Phosphorus (P) level was determined by colorimetric ally using Vanadomolybdate method (Kitson and Mellon, 2004).

Result and Discussion

The moisture content of sample A is lower than other samples which means that the presence of soybeans and catfish have effect on the moisture content. The Ash, protein and fat content of sample C is higher than others while sample E is next, this shows that inclusion of catfish increases the Ash, protein and fat content agrees with Malomo and Abiose(2019). The carbohydrate in sample A is much higher than other samples

Table 1: Proximate compositionof maize masa enriched with soybeans and dried catfish

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Fibre (%)	Energy (kcal/g)
A	3.71±0.71 ^b	0.73±0.04 ^c	2.58±0.03 ^c	7.61±0.01 ^e	83.53±0.71 ^a	1.84±0.20 ^a	387.78±7.11 ^a
B	6.49±0.14 ^a	1.70±0.28 ^{ab}	5.62±0.03 ^a	21.18±0.00 ^c	63.55±0.28 ^c	1.46±0.84 ^b	389.5±7.55 ^a
C	5.39±0.28 ^b	2.04±0.57 ^a	5.74±0.57 ^a	23.62±0.00 ^a	64.19±1.41 ^c	1.02±0.70 ^c	402.9±1.41 ^a
D	6.01±0.71 ^a	1.46±0.04 ^b	5.11±0.14 ^b	13.56±0.00 ^d	73.10±0.08 ^b	0.76±0.85 ^{cd}	392.63±7.07 ^a
E	4.04±0.85 ^c	1.78±0.28 ^{ab}	5.49±0.14 ^a	23.28±0.00 ^b	64.71±0.71 ^c	0.70±0.07 ^d	401.42±5.90 ^a

Means with different superscript in the same column are significantly different at $p < 0.05$. Sample A= 100% maize masa; Sample B=70% maize, 10% catfish, 20% soybeans masa; Sample C= 70% maize, 20% catfish, 10% soybean masa; Sample D= 80% maize, 10% catfish, 10% soybean masa; Sample E= 70% maize, 15% catfish, 15% soybean masa.

Table 2 Mineral Compositionof maize masa enriched with soybeans and dried catfish

Samples	Potassium(mg/100g)	Phosphorus (mg/100g)	Calcium (mg/100g)
A	4.62±0.28 ^{bc}	7.37±0.28 ^b	0.69±0.00 ^b
B	5.09±0.01 ^a	7.51±0.01 ^c	0.72±0.14 ^a
C	4.82±0.28 ^c	8.09±0.03 ^a	0.69±0.06 ^b
D	4.94±0.00 ^b	7.64±0.28 ^b	0.60±0.00 ^d
E	5.39±0.06 ^a	7.58±0.01 ^c	0.68±0.04 ^c

Means with different superscript in the same column are significantly different at $p < 0.05$
KEY: Sample A= 100% maize masa; Sample B=70% maize, 10% catfish, 20% soybeans masa; Sample C= 70% maize, 20% catfish, 10% soybean masa; Sample D= 80% maize, 10% catfish, 10% soybean masa; Sample E= 70% maize, 15% catfish, 15% soybean masa.

Table 2 shows the mineral result, there is increase in mineral especially percentage of potassium in samples B and E, which have more soybeans while sample A has less percentage of the minerals considered. Calcium content of the five samples on the other hand varied from 0.60-0.72 mg/kg with sample B the highest and sample D the lowest.

Conclusion

This research demonstrated that inclusion of soybeans and dried catfish have positive influence in the proximate and mineral qualities of maize masa

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**EFFECTS OF PARTICLE SIZE AND REHYDRATION TIME ON SOME
PHYSICAL AND ANTI-NUTRITIONAL PROPERTIES OF SOYMILK
DEVELOPED FROM AN INTERMEDIATE SOYBEAN PRODUCT**

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ABSTRACT

*Soybean seeds (*Glycine-max*) were processed into a powdered intermediate soybean product (ISP) of three different particle sizes (150 μ m, 200 μ m and 250 μ m). The intermediate soybean products were then rehydrated by steeping in warm water each at three different periods; 1 hour; 3 hours and 6 hours. The soymilk obtained from this rehydrated ISPs were then evaluated for their physical and anti-nutritional properties. Results of the physical and anti-nutritional properties of the soymilk samples gave: Total soluble solids (TSS) ranging from 8.50 to 10.80%; the specific gravity ranged from 1.06 for the control samples to 1.01 for the samples processed using the 60 mesh aperture and stepped for 1 hour; the pH of the soymilk samples varied between 6.5 for control to 6.6 for the samples processed with the intermediate soybean product; the phytate activity (PHA) ranged from 2.32-3.19mg/ 100g; the alkaloid content was 2.05-2.15mg/ 100g and the oxalate activity (OXA) was in the range of 0.09-0.17mg/ 100g.*

Keywords: Soymilk, Intermediate Soybean Products, Particle Size, Rehydration Time, Physical and Anti-Nutritional Properties.

Introduction

Soybean (*Glycine-max*) has been exploited for the manufacture of food products such as soymilk, soy-cheese, soy-ogi, soy-cake, soy-flour, soy-cookies and bread among others.

Soymilk, a popular beverage from soybean has been reported to be the most popular of these products in Nigeria because of its refreshing and nutritious nature. Soymilk is a highly nutritious food drink which contains protein, fat, carbohydrates vitamins and minerals. It is such a nutritiously valued and of a comparatively low cost that it plays an important role in the dietary pattern of people in most developing countries (Momoh et al.,2011).

Processing of soybeans into soymilk involves the traditional wet milling of a previously sorted, stepped and parboiled soybean and then flitting and pasteurizing the milky extract from the wet milled material which may then be flavored before serving (Momoh et al.,2011).

The wet milling aspects, often done by road side operators is usually inherent with hygienic concerns and often leads to a product of short shelf life thus making the production line unattractive.

Advancing a new method by which soymilk can be produced from soybeans without necessarily involving the wet milling aspect will be a welcome development in the food

industry especially at the cottage level. The technology of an intermediate product has been exploited for years in the food industry for generating shelf stable semi-processed consumer goods which can then be further processed into a desired end product. Processing soybeans into an intermediate product from which the soymilk beverage can covalently be made at home will attract more production of this nutritious beverage and hence boost its use for the fight against protein malnutrition among the populace.

Soybeans like most legumes are known to have some anti-nutritional properties which interfere with the bio-availability of nutrient in its product. Most processing activities on soybean are therefore usually aimed at eliminating or reducing these anti-nutritional factors to as low as possible because the wholesomeness of food product developed from soybeans is judged by its level of its anti-nutritional characteristics.

This work therefore is designed to produce soymilk from an intermediate soybean product and to evaluate some physical and anti-nutritional properties of soymilk obtained from an intermediate soybean product.

Materials and Methods

Sourcing and Pretreatment of Soybean Seeds

Soybeans seeds (Glycine-max) were purchased from the grain section in Eke Market Afikpo, Afikpo North Local Government of Ebonyi State, Nigeria. The seeds were sorted to remove extraneous materials and defective samples. The sorted seeds were washed and steeped in portable water for 8 hours. The steeped beans were drained and parboiled for 20 minutes. The parboiled seeds were then dived into 2 portions.

Processing of Soybean into an Intermediate Soybean Product

The first portion of the parboiled soybeans was subjected to drying at 70°C in a conventional oven. The drying was continued until the grains became friable such that the hulls could easily come off. The dry grains were then sent to a disc mill, where it was dehulled and dry milled into powder. The powdered material was divided into 3 equal batches and each batch was sieved using a different sieve aperture sizes to generate a given particle size of the powdered material. The 3 sieve aperture sizes used were; 100mesh ($\approx 150\mu\text{m}$), 70mesh ($\approx 200\mu\text{m}$) and 60mesh ($\approx 250\mu\text{m}$). The sieve materials were packaged and labeled appropriately as intermediate soybean product (ISP). The sieve materials were packaged and labeled appropriately as intermediate soybean product (ISP) indicating the three different sieve aperture sizes

Production of soymilk from intermediate soybean product (ISP)

The intermediate soybean product from each batch was then rehydrated by stepping one parts of the ISP in 5 parts of warm water at 50°C each at 3 rehydration period which were 1hour, 3hours and 6hours. Soymilk was then obtained from each of the rehydrated samples by squeezing through a double folded muslin cloth to obtain their milky extracts. The milky extracts was pasteurized at 65°C for 30 minutes, cooled and bottled for further analysis. The

second portion of the parboiled soybean was also processed into soymilk following the traditional wet milling method to serve as the control.

Determination of Physical Properties of Soymilk Samples

The total soluble solids TSS, Specific-gravity and pH of the soy-milk were determined following the standard procedures. TSS of soymilk samples were determined by evaporating to dryness 5g of each soymilk sample over a steam bath and residue expressed as the original weight of the sample. Specific gravity of soymilk samples was determined as an expression of their weight in density bottle over the weight of an equal volume of water in the density bottle. The pH of soymilk samples were read directly by the use of a portable pH meter (Model No: 206 PH2 Chinese pen-like Ph reader).

Determination of Anti-Nutritional Properties in Soymilk Samples

The phytate activity (PHA) in soymilk samples were determined by the standard method of (AOAC 2010). While the oxalate and alkaloids properties were determined by the method adopted by (Ogbukonwu et al.,2021).

Statistical Analysis

Data generated were statistically analyzed using the Analysis of Variance. Mean values were subjected to one way Analysis Of Variance (ANOVA) at 5% level of significance using SPSS 17.0 software for windows. Mean values were separated using Duncan's multiple range tests.

Results and Discussion

Table 1: shows some physical and anti-nutritional properties of the soymilk samples produced from the intermediate soybean product of various particle sizes (PS) and rehydration times (RT).

Table 1: Physical and Anti-Nutritional Properties of Soymilk Samples

Sample	TSS(%)	SP. GR.	pH	PHA(mg/100g ⁻¹)	Akl(mg/100 ⁻¹)	Oxa(mg/100 ⁻¹)
SA1	9.50 ^b ±0.03	1.01 ^c ±0.07	6.6 ^b ±0.08	3.17 ^a ±0.08	2.05 ^b ±0.07	0.17 ^a ±0.01
SA3	10.1 ^a ±0.01	1.03 ^c ±0.06	6.6 ^b ±0.07	3.06 ^{ab} ±0.08	2.05 ^b ±0.07	0.13 ^a ±0.02
SA6	10.6 ^a ±0.01	1.05 ^a ±0.08	6.5 ^a ±0.09	2.32 ^b ±0.01	2.05 ^b ±0.07	0.07 ^b ±0.06
MA1	9.0 ^c ±0.02	1.01 ^c ±0.09	6.6 ^b ±0.08	3.18 ^a ±0.03	2.05 ^b ±0.07	0.17 ^a ±0.01
MA3	9.2 ^c ±0.01	1.02 ^c ±0.08	6.6 ^b ±0.07	3.10 ^{ab} ±0.01	2.05 ^b ±0.07	0.15 ^a ±0.03
MA6	9.6 ^b ±0.01	1.04 ^b ±0.05	6.5 ^a ±0.08	2.36 ^b ±0.04	2.05 ^b ±0.07	0.09 ^b ±0.08
LA1	8.5 ^d ±0.05	1.01 ^c ±0.08	6.6 ^b ±0.05	3.19 ^a ±0.03	2.05 ^b ±0.07	0.17 ^a ±0.01
LA3	8.8 ^c ±0.06	1.02 ^c ±0.07	6.6 ^b ±0.06	3.11 ^a ±0.03	2.05 ^b ±0.07	0.16 ^a ±0.05

LA6	9.2 ^b ±0.04	1.03 ^c ±0.06	6.5 ^a ±0.08	2.40 ^b ±0.02	2.05 ^b ±0.07	0.10 ^b ±0.09
CON	10.8 ^a ±0.01	1.06 ^a ±0.05	6.5 ^a ±0.09	2.35 ^b ±0.05	2.15 ^a ±0.01	0.11 ^b ±0.09

Values with same superscript in the same column are not significantly different from each other (at $p \leq 0.05$)

KEY: SA1 = Soy milk sample made from ISP of 100mesh sieve and rehydrated for one hour.

SA3= Soy milk sample made from ISP of 100mesh sieve and rehydrated for three hours.

SA6= soy milk sample made from ISP of 100mesh sieve and rehydrated for six hours.

MA1= Soy milk sample made from ISP of 70mesh sieve and rehydrated for one hour.

MA3= Soy milk sample made from ISP of 70mesh sieve and rehydrated for three hours.

MA6 = Soy milk sample made from ISP of 70mesh sieve and rehydrated for six hours.

LA1= Soy milk sample made from ISP of 60mesh sieve and rehydrated for one hour.

LA3= Soy milk sample made from ISP of 60mesh sieve and rehydrated for three hours.

LA6= Soy milk sample made from ISP of 60mesh sieve and rehydrated for six hours.

CON = Controlled soya milk processed using traditional method

The result shows that the total soluble solids (TSS) range from 8.5-10.6%. Soymilk samples generated from intermediate soybean product of the 100mesh aperture size seem to contain more TSS than the other aperture sizes.

Generally, percentage TSS in soymilk samples seem to increase with increasing rehydration time for each given aperture size. However percentage TSS for soymilk sample process with the 100mesh sieve and rehydrated for 3 and 6 hours were significantly (at $p \leq 0.05$) higher than the other samples but were not significantly (at $p \geq 0.05$) greater than the control processed using the traditional wet milling method. The total soluble solid is an indication of dissolved nutrient which can be obtained from the product. The percentage TSS of 10.9 and 11.1 reported in this work are however close to the values reported by (Shahnai et al., 2020)..

The specific gravity (SP.GR.) of the soymilk samples ranged from 1.06 from the control samples to 1.01 from the samples processed using the 60mesh aperture and stepped for 1 hour. Variation of specific gravity value in the milk sample was very narrow. However the control sample and the sample processed using the 100mesh aperture and rehydrated for 6 hours were not significantly different (at $p \geq 0.05$) from each other but were significantly different (at $p \leq 0.05$) from the other samples. The specific gravity can be used as an index of soluble solid in a heterogonous solution. The range of specific gravity value of 1.01-1.05 reported in this work is also close to the value of 1.02 as report by (Shahnai et al., 2020).

The pH of the soymilk samples varied between 6.5 for control to 6.6 for the sample processed using the intermediate soy-milk product. According to (Ari et al.,2012). the pH of soymilk sample is a measure of its protein quality. The pH of the soymilk sample rehydrated for 6 hours seem to be significantly (at $p \leq 0.05$) lower than the sample rehydrated at lesser periods. However the pH value of 6.5-6.6 obtained in this work was close to the value of 6.5 as reported by (Shahnai et al., 2020).

The phytate activity (PHA) of the soymilk sample ranged from 2.32-3.19mg/100g. The PHA value seem to decrease with increasing rehydration period for each given particle size of the intermediate soybean product (ISP). However the range of phytate activities obtain in this work is close to the value of 3.17 as reported by (Ogbukonwu et al., 2021).

The Alkaloid content of soymilk samples made from the intermediate soybean product did not differ significantly (at $p \leq 0.05$) from one another but were significantly different (at $p \geq 0.05$) higher than that of the control. However the alkaloids content of the soymilk samples of 2.05-2.15 obtained in this work was lower than that of 1.13-1.63 as reported by (Okwu et al., 2007).

Oxalate activity of soymilk samples (OXA) ranged between 0.09-0.17mg/100g, as the oxalate of the soymilk samples seem to decrease with increase in rehydration period for each batch of particle sizes. The range of OXA values in soymilk samples obtained in this work ranked closely with the range of OXA of 0.07-0.17mg/100g as reported by (Ogbukonwu et al., 2021).

According to Humyra et al. (2018), the phytate, alkaloid and oxalate properties of a soybean product is a measure of its protein solubility and mineral availability in the product. Thus the lower the content of this anti-nutritional compounds in a soybean product the more its nutrient availability to consumers.

Conclusion

Soy milk product of acceptable physical and anti-nutritional properties was obtained from an intermediate soybean product using different particle size and rehydration period. Total soluble solids and specific gravity of soymilk samples increase significantly (at $p \leq 0.05$) with smaller particle sizes, whereas the pH value and anti-nutritional properties decreased significantly (at $p \geq 0.05$) with increasing rehydration time for the same given particle size. The physical and anti-nutritional properties of soymilk samples process obtained from the traditional wet milling method were not significantly different (at $p \leq 0.05$) from the soymilk samples obtained from the intermediate soybean product of the 100mesh particle size and a rehydration time of 3 and 6 hours.

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PROTEIN IMPROVEMENT OF GROUNDNUT SHELLS BY FERMENTATION USING *TRICHODERMA SPP.*

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Abstract

Environmental pollution from agricultural wastes has necessitated concern for bioconversion to valuable products. Solid state fermentation of groundnut shells was carried out for 8 days, using *Trichoderma spp.* Sample from fermented biomass was collected, oven dried at 60°C, cooled and assayed for proximate and amino acid composition. The unfermented groundnut shells were also subjected to analyses. The crude protein, fat, fibre, ash and carbohydrate content increased significantly ($p < 0.05$) from 6.35%, 0.94%, 0.64%, 1.98% and 84.6% to 7.79%, 1.30%, 0.79%, 2.43%, and 86.86% respectively after fermentation. The total amino acid concentration of fermented groundnut shell (74.46mg/100g) was significantly ($p < 0.05$) higher than that of the unfermented groundnut shell (71.70mg/100g). Therefore, the fermented groundnut shell could serve as a cheap protein source for enriching livestock feed. This could also aid in minimizing environmental pollution associated with the disposal of groundnut shells.

Keywords: Groundnut shells, *Trichoderma spp.*, fermentation and amino acids.

Introduction

Large amount of lignocellulosic waste that pose environmental pollution problem are generated through forestry and agricultural practices of many agro-based industries. Interests in recovery of waste or by-products have been increasing for economic, ecological as well as nutritional reasons. In the last two decades, there have been concerted efforts at finding ways of complete utilization of agro-industrial by-products, which sometimes constitute environmental hazards (Iyayi and Lose, 2001).

Groundnut shells are the leftover product obtained after the removal of groundnut seeds from their pods. This is an abundant agro-industrial waste product which has a very slow degradation rate under natural conditions. Fermentation is an essential technology required for converting lignocellulosic materials such as groundnut shell into value-added products with great potential to provide solutions to problems of animal nutrition and also reduce pollution (Anupama and Ravindra, 2000). *Trichoderma* species are highly efficient producers of many extracellular enzymes. They are used commercially for production of cellulases and other enzymes that degrade complex polysaccharides. The desire for biotransformation of wastes into valuable products like protein-enriched products and ensuring desirable environmental sanitation necessitated this research. This research therefore was aimed at developing a protein-rich product by fermenting groundnut shells with *Trichoderma spp.*

Materials and Methods

Groundnut shells were collected from groundnut processing area in New Bussa, Borgu L. G. A., Niger State. It was weighed and dried in the open air for 3 days. Dried groundnut shells were milled and sieved to obtain the desired particle size of 0.1-0.5mm. The sample was packed in a polythene bag and stored at -20 °C until analyzed.

Fermentation protocol

Solid state fermentation was carried out according to the method of Saxena and Singh, (2011) with some modifications. Fifty grams (50 g) of substrate (Groundnut shell powder) was added to 250 ml Erlenmeyer flasks, moistened with 30 ml of sterile distilled water, and autoclaved at 121 °C at 15 psi for 15 mins. Each flask was then inoculated with 10 ml *Trichoderma spp.* culture. Fermentation was carried out at ambient temperature (28 ± 2 °C) for 8 days under static condition (without agitation). The fermented mass was oven-dried at 60 °C for 8 h and packaged in labeled polythene bag.

Chemical Analysis

Crude protein, crude fiber, moisture content, ash, fat and nitrogen free extract of both fermented and unfermented groundnut shells were determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Amino acid composition was determined according to standard procedures.

Results and Discussion

The results of the proximate analysis (Table 1) indicate an increase in the ash content from 1.98% to 2.43%. This is in consonance with the work of Morawiki (2018) who reported an increase in ash content in cassava product using *Saccharomyces cerevisiae*. The increase in ash content could be suggestive of microbial activity. Crude fibre content increased from 0.64% to 0.79% in fermented groundnut shells. The result obtained from this work is contrary to the findings of Olutosin and Kayode (2021) who reported a decrease in the crude fibre. Fermentation increased the protein content from 6.35% to 7.79%. The result agrees with Osama *et al.* (2013) who used *Trichoderma harizianum* as strain on different agro-industrial wastes under solid state fermentation. The fat content increased from 0.94% to 1.30% after fermentation. The increase in the fat content might be due to increase in the microbial mass most especially the activities of lipolytic microorganisms which secrete extracellular enzymes (lipase), consequently releasing oil into the fermenting medium and other products of metabolism.

The amino acid profile of the fermented and unfermented groundnut shells is presented in Table 2. The results showed that both fermented and unfermented groundnut shells contain essential and non-essential amino acids. Glutamic acid was the most abundant amino acid in fermented (11.42mg/100g) and unfermented (10.27mg/100g) groundnut shells. Aruna *et al.* (2017) had reported similar results when yam peels were fermented with *Saccharomyces cerevisiae*. The total amino acids concentration (74.46mg/100g) of fermented groundnut shell was significantly ($p < 0.05$) higher than that (71.70mg/100mg) of the unfermented groundnut shell. Higher composition of amino acid in fermented groundnut shell over the unfermented groundnut shell could be as a result of the presence of high protein fungal biomass in the fermented groundnut shell. Similar results were observed by Ezekiel *et al.* (2010) when cassava peels were fermented with *Trichoderma viride*. These values of essential amino acids suggest that they can be used for animal feed if other nutrients are adequate (Izah, 2018). Groundnut shells when fermented can therefore serve as a valuable source of amino acids in livestock feed.

Table 1: Proximate composition of raw and fermented groundnut shells

Samples	Moisture (%)	Ash (%)	Fibre (%)	Protein (%)	Fat (%)	Nitrogen free extract (%)
Un-Fermented groundnut shells	5.50±0.50 ^a	1.98±0.01 ^b	0.64±0.00 ^b	6.35±0.04 ^b	0.94±0.06 ^a	84.60±0.49 ^b
Fermented Groundnut Shells	0.83±0.29 ^b	2.43±0.01 ^a	0.79±0.00 ^a	7.79±0.04 ^a	1.30±0.53 ^a	86.86±0.23 ^a

Data presented on dry matter basis. The values are means and standard deviationsof three independent determinations. Means followed by the same superscriptsdwn the column are not significantly different ($p>0.05$).

Table 2: Amino acid composition (mg/100g) of raw and fermented groundnut shells

Amino acid	Unfermented Groundnut shell (Control)	Groundnut shells fermented with <i>Trichoderma spp.</i>
Leucine ^x	7.37±0.06 ^b	7.84±0.04 ^a
Lysine ^x	4.09±0.08 ^a	3.61±0.04 ^b
Isoleucine ^x	3.16±0.06 ^b	3.37±0.04 ^a
Phenylalanine ^x	4.09±0.01 ^a	3.86±0.06 ^b
Tryptophan ^x	0.84±0.04 ^a	0.75±0.02 ^b
Valine ^x	3.99±0.14 ^b	4.25±0.06 ^b
Methionine ^x	1.40±0.06 ^b	1.63±0.04 ^a
Proline ^y	2.38±0.07 ^a	2.34±0.01 ^b
Arginine ^y	5.59±0.11 ^b	6.37±0.01 ^a
Tyrosine ^y	3.27±0.01 ^a	3.18±0.13 ^b
Histidine ^x	2.11±0.09 ^a	1.82±0.05 ^b
Cystine ^y	1.05±0.06 ^b	1.18±0.04 ^a
Alanine ^y	3.69±0.29 ^b	4.44±0.05 ^a
Glutamic acid ^y	10.27±0.05 ^b	11.42±0.32 ^a
Glycine ^y	3.73±0.03 ^b	3.43±0.05 ^a
Threonine ^y	3.03±0.04 ^b	3.34±0.06 ^a
Serine ^y	4.08±0.12 ^b	3.45±0.05 ^b
Aspartic acid ^y	7.57±0.12 ^b	8.18±0.85 ^a
Total amino acid content	71.70	74.46

Values are means with standard deviations. Values with different superscript letters in a column vary significantly at $P<0.05$.^x- Essential amino acid, ^y- Non-essential amino acid.

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RHEOLOGICAL PROPERTIES OF SURFACTANT-ASSISTED ENZYMATICALLY EXTRACTED TIGER NUT MILK

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ABSTRACT

Tiger nut milk (TNM), a vegetable imitation of milk, is gaining global attention due to its nutritional and bio-functional qualities. Consequently, efforts aimed at improving its production is increasing. This study investigated the flow behaviour properties of surfactant-assisted enzymatically extracted TNM. Tiger nut milk was extracted from tiger nut using xylanase alone, xylanase + surfactant (Tween 20), or without xylanase and Tween 20 (control). The rheological properties of the resulting samples were evaluated using a standard procedure. Using xylanase alone reduced the apparent viscosity of TNM relative to the control sample. The surfactant-assisted enzymatically extracted TNM had a higher apparent viscosity compared to TNM extracted using xylanase alone. The rheological models, Power Law, Herschel Bulkley, and Casson, showed a higher viscosity reduction rate in TNM extracted using xylanase alone compared to the surfactant-assisted enzymatically extracted TNM. Surfactant-assisted enzymatic protocol could prove effective in the extraction of TNM with improved rheological properties.

Keywords: *Cyperus esculentus*, Flow properties, Tween 20, Xylanase

INTRODUCTION

Tiger nut milk (TNM), a vegetable imitation of milk, is gaining global attention due to its nutritional, bio-functional, and aesthetic qualities. TNM is produced from tiger nut (*Cyperus esculentus*), a rhizome found in many parts of Africa and Europe (Neto *et al.*, 2019). TNM is extracted from the nut after soaking and wet-milling. The use of enzymes, such as amylase and xylanase, has been reported to facilitate extraction, save time, and energy; therefore, considered a better extraction procedure compared to the conventional mechanical extraction protocol (Kizzie-Hayford *et al.*, 2018).

Xylanase is the most important hemicellulase that degrades xylan by randomly acting on its β -1-4 non-reducing terminal section of the glycosidic bonds of glucose units (Silva *et al.*, 2019). Enzymatic extraction often alters the physicochemical properties of juices (Weber and Larsen, 2017), therefore, an improvement of the enzymatic extraction process for improved product quality is imperative, and the use of surfactant-mediated enzymatic extraction could prove effective in this regard.

Surfactants are amphiphiles that are made up of discrete lipophilic and hydrophilic moieties, which form stable aggregates with monomers in an aqueous solution (Paleologos, 2017). Polyoxyethylenesorbitanmonolaurate (Tween 20) is commonly used in the food industry due to its non-toxicity, availability, low cost, and biodegradability (Eskandani *et al.*, 2013). In our previous study (Adedjei *et al.*, 2022); a surfactant-assisted enzymatic protocol for extracting TNM from tiger nuts was established using different concentrations of xylanase (0.010-0.100%) and Tween 20 (0.005-0.010%). Optimum yield, macronutrients, phytochemicals, and antioxidant properties were obtained using 0.010% xylanase and Tween 20. This current study investigated the rheological properties of surfactant-assisted enzymatically extracted TNM.

MATERIALS AND METHODS

Surfactant-assisted enzymatic extraction of tiger nut milk

The tiger nuts (yellow variety, sourced from Wukari, Nigeria) were thoroughly washed with potable water to remove soil particles. Subsequently, 1 kg of cleaned tiger nuts was soaked in 4 L distilled water containing 10 mL 0.5% citric acid (Klincent Laboratory, India) for 12 h. The nuts were separated and washed twice with potable water (20 °C) and milled with a Waring blender (Model 8010EX, Clarkson Inc., California, US) for 15 min to obtain a coarse mush. To facilitate the milling operation, 200 mL distilled water was added intermittently. TNM was extracted from the mush with the aid of 0.01%, v/w of mush, xylanase (produced from *Aspergillus oryzae*, Sigma-Aldrich, St. Louis, MO 631303, USA), with or without 0.010% v/w Tween 20 (CAS No. 9005-64-5, Sigma-Aldrich, St. Louis, MO 631303, USA). The TNM extracted without xylanase and Tween 20 served as the control sample.

Rheological characterisation of tiger nut milk

The protocol described by Sharoba and Ramadan (2011) was used for the evaluation of the rheological properties of TNM samples. Briefly, 20 mL of TNM, at various temperatures (10, 20, 30, and 40°C), was sheared at 102.2-510.9 s⁻¹ shear rate in a viscometer (Haake RV 20 Rotovisco, Thermo Electron GmbH, Karlsruhe, Germany). The shear stress and apparent viscosity of the sample were read-off from the equipment's screen. Power Law (Eq. 1), Herschel-Bulkley (Eq. 2), and Casson (Eq. 3) models were used for the estimation of flow behaviour index, *n*, consistency index, *k* (Pa.s), and yield stress, τ_0 (Pa). The suitability of the models was determined by calculating the correlation coefficient (*R*²).

$$\tau = k\gamma^n \quad (1)$$

$$\tau = \tau_0 + k\gamma^n \quad (2)$$

$$\tau^{0.5} = \tau_0^{0.5} + k\gamma^{0.5} \quad (3)$$

Where τ and γ are shear stress (Pa) and shear rate (s⁻¹), respectively.

RESULTS AND DISCUSSION

Figure 1 shows a reduction in apparent viscosity with an increasing shear rate, suggesting a shear-thinning pseudoplastic behaviour (Sharoba and Ramadan, 2011), corroborating a report that fermented TNM exhibited shear-thinning behaviour (Kizzie-Hayford et al., 2016). There was variation in the shear-thinning behaviour of TNM based on the extraction procedure. The control sample had the highest apparent viscosity at all the shear rate values, implying that enzymatic extraction significantly reduced viscosity probably due to the degradation of complex molecules, such as xylan, pectin, and starch, having high viscosity, to simple less-viscous molecules. The presence of surfactant interfered with the activity of xylanase during extraction. This was evident in the higher viscosity of the surfactant-assisted enzymatically extracted TNM relative to the one extracted with xylanase alone, likely because of the encapsulating effect of surfactant on starch molecules. This could be advantageous in preventing phase separation of TNM that would have occurred due to increased enzyme action (Kizzie-Hayford et al., 2018).

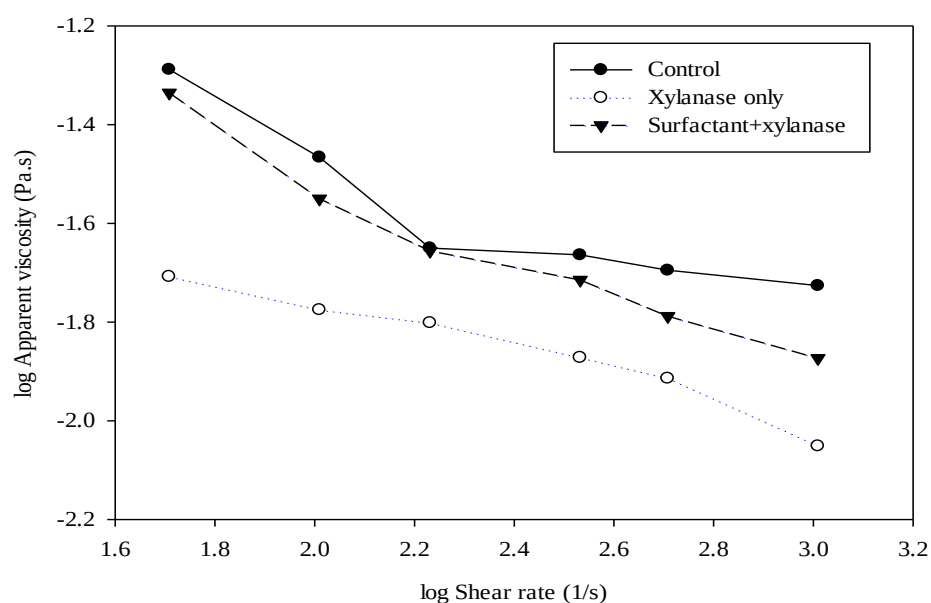


Figure1. Apparent viscosity of surfactant-assisted enzymatically extracted tiger nut milk. Control: tiger nut milk extracted without xylanase and Tween 20.

The flow characteristics of TNM, as described by the Power Law, Herschel Bulkley, and Casson models, are shown in Table 1. The Power Law and Herschel Bulkley models show an increase in flow behaviour index and a reduction in consistency index following enzymatic extraction of TNM, suggesting viscosity reduction. Viscosity reduction was most pronounced in the xylanase-extracted TNM, likely because of increased xylan degradation, suggesting a reduction in shear-thinning behaviour that could increase phase separation, hence a reduction in stability and organoleptic properties (Adedje et al., 2022). The inclusion of Tween 20 during enzymatic extraction favoured the shear-thinning attribute, as indicated by higher viscosity relative to the use of xylanase alone, likely to the creation of a stable lipophilic and hydrophilic dispersion.

The yield stress reduced following enzymatic extraction, due to the reduction in resistance to flow following viscosity reduction (Sharoba and Ramadan, 2011), implying a reduction in energy requirement during post-processing operations, such as pumping and bottling. The surfactant-assisted enzymatically extracted TNM had significantly higher yield stress compared to the TNM extracted using xylanase alone, likely because of the encapsulating effect of the surfactant (Paleologos, 2017). A high correlation coefficient (> 0.9000) was obtained, indicating the suitability of the models for the characterisation of the flow properties of TNM.

Table 1. Flow parameters of tiger nut milk at different temperatures

Temperature (°C)	Tiger nut milk	n	Power Law K (Pa.s)	R ²	τ_0 (Pa)	n	Herschel-Bulkley K (Pa.s)	R ²	Casson K (Pa.s)	τ_0 (Pa)	R ²
10	Control	0.2591	3.9678	0.9797	2.7259	0.4081	1.6867	0.9934	0.3649	3.5063	0.9623
	Xylanase	0.4119	1.5450	0.9948	0.1642	0.4294	1.4159	0.9942	0.4307	1.1204	0.9952
	Surfactant+xylanase	0.2925	3.3102	0.9510	1.9067	0.4057	1.7500	0.9571	0.3939	2.8066	0.9411
20	Control	0.2505	3.8152	0.9435	2.6322	0.3626	1.8011	0.9259	0.3455	3.3713	0.9223
	Xylanase	0.4535	1.2491	0.9827	0.2450	0.4868	1.0662	0.9826	0.4520	0.8187	0.9801
	Surfactant+xylanase	0.2659	3.2950	0.9060	2.1927	0.4040	1.4755	0.9100	0.3454	2.8850	0.9095
30	Control	0.1981	4.0654	0.9459	3.3593	0.3982	1.1624	0.9736	0.2621	3.7815	0.9288
	Xylanase	0.4522	1.1590	0.9775	0.0966	0.4662	1.0847	0.9769	0.4267	0.7909	0.9845
	Surfactant+xylanase	0.3158	2.6565	0.9255	1.3751	0.4152	1.5416	0.9257	0.3898	2.2061	0.9261
40	Control	0.2210	3.4398	0.9969	3.6080	0.3935	0.9277	0.9181	0.2151	3.8963	0.8945
	Xylanase	0.4482	1.0485	0.9890	0.1138	0.4664	0.9616	0.9884	0.4031	0.7091	0.9922
	Surfactant+xylanase	0.3273	2.2835	0.9238	1.1928	0.4317	1.3142	0.9255	0.3752	1.9003	0.9238

Control: tiger nut milk extracted without xylanase and Tween 20.

Conclusions

This study showed an improvement in the flow properties of TNM following its extraction using a surfactant-assisted enzymatic procedure. Enzymatic extraction reduced viscosity. A higher viscosity was obtained for the surfactant-assisted enzymatically extracted TNM relative to the one extracted with xylanase alone. A high correlation coefficient (> 0.9000) was obtained for all the samples, indicating the suitability of Power Law, Herschel-Bulkley, and Casson for the characterisation of the flow properties of TNM.

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COMPARATIVE EVALUATION OF THE PROXIMATE COMPOSITION AND SELECTED FUNCTIONAL PROPERTIES OF PROTEIN CONCENTRATES OF DEFATTED AND FERMENTED TIGER NUT (*Cyperus esculentus*) and PIGEON PEA (*Cajanus cajan*) SEEDS.

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Abstract

The proximate composition of protein concentrate obtained from defatted and fermented tiger nut and pigeon pea were investigated. Tiger nut and pigeon pea were milled into flour, defatted and subjected to spontaneous fermentation for 24 hours after which protein concentrates were obtained from the flours using standard methods. The proximate composition and some functional properties were determined and data obtained were statistically analyzed using t-test. Results showed that pigeon pea protein concentrates had significantly ($p \leq 0.05$) higher contents (42.00%) compared to that of tiger nut (28.17%). There were no significant differences ($p \geq 0.05$) observed in the Fat, Ash and Crude fibre content of both concentrates. Tiger nut showed significantly ($p \leq 0.05$) higher levels of carbohydrates (59.86%) in contrast to pigeon pea (43.30%). Pigeon pea protein concentrate exhibited better functional properties in all the parameters measured excluding bulk density and oil absorption capacity.

Keywords: Tiger nut, pigeon pea, protein, proximate, functional

1.0 Introduction

Protein Energy Malnutrition (PEM) known as "the silent emergency of the globe," is by far the deadliest type of malnutrition and may have stalked humanity from the beginning of time. There is an imbalance between the amount of protein and energy available and what the body needs to grow and function at its best. With moderate to severe forms, it is currently the most prevalent and dangerous health issue affecting children worldwide. (Aderonke *et al.*, 2014)). The current issues with food security and malnutrition, as well as population growth, the high cost of animal-based food, globalized migration, restrictions brought on by allergies, and dietary preferences, have pushed for the discovery and incorporation of new protein sources to enhance conventional formulations and diversify consumer good (Toewset *et al.*, 2013).

Protein concentrates are used as ingredients to improve the nutritional value and sensory characteristics of food products (Boyet *et al.*, 2010). The production of plant protein concentrates is of great interest in the food industry due to the increased requirement for protein and increasing applications of plant derived proteins in foods, especially in developing countries (Kumar *et al.*, 2014).

Pigeon pea (*Cajanus cajan*) has a high protein content and is a healthy source of carbohydrate, fiber, and minerals (Mueller *et al.*, 2015) Pigeon pea seeds can contain between 18% and 22% of their total weight in proteins which consist of essential amino acids such as lysine, valine, threonine and phenylalanine. The primary storage proteins in pigeon pea seeds are globulin proteins. (Kesari *et al.*, 2017).

Tiger nuts (*Cyperus esculentus*) are underutilized and are prized for their very nutritious composition. According to reports, the nuts are rich in proteins, sucrose and fats that are

resistant to oxidation. (Adegunwa *et al.*, 2017). Tiger nuts have been shown to have more essential amino acids than those recommended in the FAO/WHO protein standard, including lysine, cystine, arginine, and histidine (Adegunwa *et al.*, 2017).

Functional properties are the fundamental physicochemical characteristics that take into account the intricate interactions between the composition, structure, molecular conformation, and physico-chemical characteristics of food components, as well as the characteristics of the environment in which these are related to and measured. Functional parameters are necessary to assess potential behavior of proteins, fats, fibers, and carbohydrates in particular systems. (Suresh, 2013). The aim of this paper was to compare the proximate composition and functional properties of protein concentrates obtained from defatted and fermented pigeon pea and tiger nut seeds.

2.0 Materials and Methods

2.1 Materials

Tiger nut was purchased from Kure Modern Market, Minna while Pigeon pea was purchased at Farin Gada Market in Jos.

2.2 Methods

2.2.1 Sample preparation and analysis

Pigeon pea and tiger nuts were sorted to remove all the extraneous substances, cleaned and milled into flour using a disc attrition mill. The flours were first defatted using a soxhlet apparatus as described by AOAC (2012). The defatted flours were fermented (solid state) at room temperature ($28 \pm 2^\circ\text{C}$) using the method described by Katina *et al.* (2012). After the fermentation, protein concentrates were then extracted from the flour using the method described by Ocheme *et al.* (2018). The protein concentrates were then packed in ziploc bags and stored in a refrigerator. The proximate composition and some functional properties of the protein concentrates were determined according to the methods described by AOAC (2012) and Onwuka (2005) respectively.

2.2.2 Statistical analysis

Data obtained were subjected to t-test.

3.0 Results and Discussion

The proximate composition of pigeon pea and tiger nut protein concentrates are found in Table 1.0. Significant differences ($p \leq 0.05$) were observed in the protein content of both concentrates as shown in Table 1 with pigeon pea having the higher value of 42.00 ± 1.19 compared to those of tiger nut (28.17 ± 1.19). Akubor (2017), in his research reported a crude protein content of pigeon pea flour of 23.0% for raw pigeon pea flour and 28.8% for fermented pigeon pea. These values were lower than those recorded in this study which was 42.00%. In another study by Aremu (2015) on raw and cooked tiger nut he reported crude protein content values lower than those gotten from this research (12.09% and 9.25% respectively). The wide variation between the pigeon pea and tiger nut protein concentrates could be as a result of the class of crops it belongs to, as legumes have higher protein contents than tuber cereals (Mueller *et al.*, 2015). Although there were no significant differences ($p \geq 0.05$) observed in the Fat, Ash and Fibre of the concentrates, tiger nut showed higher levels in the stated compositions. The carbohydrate content of the protein concentrates were 43.3% and 59.86% for pigeon pea and tiger nut respectively. There was a significant difference ($p \leq 0.05$) observed among the samples. Tiger nut being a cereal tuber explains why this is so.

Table 1.0 Proximate composition of pigeon pea and Tiger nut protein concentrates

Parameters (%)	Pigeon Pea	Tiger nut
Crude Protein	42.00 ±1.19 ^a	28.17±1.19 ^b
Fat	3.84±0.12 ^a	4.33±0.12 ^a
Ash	1.50±0.53 ^a	1.95±0.53 ^a
Fibre	1.05±0.35 ^a	1.30±0.35 ^a
CHO	43.30±1.45 ^b	59.86±1.45 ^a

The functional properties of pigeon pea and tiger nut protein concentrates are shown in Table 2. Bulk density is a expression of the load the samples can carry if allowed to rest directly on one another. It is generally affected by the particle size and the density of the material (Adenekan 2017). There was no significant difference ($p \geq 0.05$) in the bulk densities of the samples nevertheless the results compared favourably with works done by Oladele and Aina 2007 on tiger nut and Adenekan 2017 on pigeon pea. Such low bulk densities (0.55g/cm^3 and 0.62g/cm^3) for pigeon pea and tiger nut makes it important in relation to packaging and would also enhance the formulation of weaning foods (Eneche & Owheru, 2005).

There was significant difference ($p \leq 0.05$) observed in the concentrates with pigeon exhibiting higher values (4.21ml/g) compared to tiger nut (3.49ml/g) which suggests that pigeon pea protein concentrate will find better application in baked products than tiger nut (Adejuyitan 2009).

Table 2 shows the oil absorption capacity of pigeon pea and tiger nut protein concentrates to be 2.47% and 2.05%. There was no significant difference ($p \geq 0.05$) observed between them. There were significant differences ($p \leq 0.05$) in the foaming and emulsifying capacity of the concentrates with pigeon pea showing higher ranges (70.27%) compared to tiger nut (66.67%). Both samples showed a downward trend in their foaming stability with increase in time. This trend was also observed in the study done by Panzimo et al., on green pigeon pea protein concentrates and matured pigeon pea protein concentrate. High foaming properties suggest that they could be attractive in products like cakes or whip creams where foaming characteristics are important. There was significant difference ($p \leq 0.05$) in the results as pigeon pea showed higher foaming stability. The emulsifying stability of both concentrates also showed a downward trend and significant difference ($p \leq 0.05$) as time increased, as pigeon pea expressed higher percentages compared to tiger nut; 82.31% at 10 min, 77.00% at 20 min and 72.51% at 30 min while tiger nut recorded 75.01% at 10 min, 70.21% at 20 min and 68.61% at 30 min. This suggests that pigeon pea protein concentrate could be a better fit as an additive for the stabilization of fat in the production of sausages, cakes or soups (Adenekan 2017).

Table 2. Functional properties of Pigeon pea and Tiger Nut protein concentrates.

Parameters	Pigeon Pea	Tiger nut
Bulk Density (g/cm^3)	0.55±0.17 ^a	0.62±0.17 ^a
Water absorption capacity (ml/g)	4.21±0.12 ^a	3.49±0.12 ^b
Oil absorption capacity (ml/g)	2.47±0.73 ^a	2.05±0.73 ^a
Foaming capacity (%)	6.93±1.98 ^a	4.95±1.98 ^b
Emulsion capacity (%)	70.27±3.60 ^a	66.67±3.60 ^b

Foaming stability (%)		
Time		
10 min	49.09±0.23 ^a	30.10±0.20 ^b
20 min	35.00±1.03 ^a	21.28±0.15 ^b
30 min	24.21±0.50 ^a	12.02±1.23 ^b
Emulsion stability (%)		
Time		
10 min	82.31±1.30 ^a	75.01±1.02 ^b
20 min	77.00±1.20 ^a	70.21±0.01 ^b
30 min	72.51±0.22 ^a	68.61±1.06 ^b

4.0 Conclusion

The results from this work points to the higher functionality of Pigeon Pea protein concentrate compared to Tiger nut. The higher foaming capacity of the protein concentrate from pigeon pea implies that it finds application in the production of cakes and whipcreams among other products where foaming characteristics are of importance. Pigeon pea showed greater water absorption capacity, signifying its potential as an ingredient in the manufacture of sausages and meat products, likewise the emulsifying capacity and stability expressed in the concentrate from pigeon pea makes it useful as an additive in the stabilization of fat in soups and cakes.

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EFFECT OF GINGER [*ZINGIBER OFFICINALE*] EXTRACT ON PHYSICOCHEMICAL AND SENSORY ATTRIBUTES OF SOY MILK YOGHURT

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Abstract

In Nigeria, soy bean is becoming one of the major crops grown and processed into varieties of products that are used to curb food insecurity. However, there is little information on processing it into yoghurt and preserving with spice. This study is design to evaluate the preservative effect of ginger extract on the physicochemical and sensory properties of soymilk yoghurt. Ginger extract was produced and included into processed soymilk yoghurt according to standard procedures, were A (99% soymilk + 1% ginger extract), B (97% soymilk + 3% ginger extract), C (95% soymilk + 5% ginger extract) and D (100% soymilk yoghurt). The yoghurts were evaluated for physicochemical and sensory properties during 10 days of storage at room temperature at 5 days intervals. The physicochemical properties ranged as follows: pH (3.91 – 4.64) and total titratable acidity (TTA) (0.98 – 1.82%). The sensory evaluation results showed that sample yoghurt A had the best panelists' rating in all the sensory properties. This study therefore infers that addition of ginger extract improved the physicochemical properties. However, addition of ginger extract at levels higher than 5% can affect the sensory attributes of the yoghurt.

Key words:

Yoghurt, Ginger extract, Microbial property, Physicochemical property and Sensory Property.

INTRODUCTION

Soy milk (also known as soy juice and soybean milk or soy drink/beverage) is a beverage made from soybeans (Patil and Jha, 2008). It is defined as an aqueous extract of whole soybeans (dehulled or non-dehulled), closely resembling dairy milk in physical appearance and composition (Patil and Jha, 2008). It is a nutritious beverage rich in high quality protein and contains no cholesterol or lactose. Soy milk is also referred to as a liquid obtained by suspending soybean in water, used as fat free substitute for milk. It is inexpensive, highly digestible, it is rich in water soluble protein, carbohydrate and oil nutrient. It is rich in polyunsaturated fatty acids, linoleic acid (Deshpande *et al.*, 2008). Soy milk fermentation is produced in a similar way to milk fermentation by adding *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* to the liquid food. Sugar fermentation causes the pH to drop, modifying the surface charge of proteins which aggregate to build a network which entraps the liquid phase and fat droplets. Yoghurt is the most popular fermented dairy product all over the world (Madhu *et al.*, 2012). Yoghurt represents an excellent source of proteins, minerals and vitamins. It is more digestible than milk due to the partial or total hydrolysis of

fat, lactose and proteins and therefore recommended for people with lactose intolerance or milk proteins allergy and it is also means of adding value to soymilk, establishing an affordable source of protein to reduce malnutrition. Yoghurt quality depends on the change observed on its physicochemical, microbiological and sensory characteristics making it a short shelf-life product due to deterioration of its properties during storage. Preservatives are added to improve yoghurt constituency, which also contributes to the shelf life of the yoghurt against microorganism attack. Addition of herbs could be an effective strategy to improve functionality of milk and milk products with respect to the health benefits, food safety and bio-preservation (Aswal *et al.*, 2012). Active ingredients like gingerols and zingerone present in ginger exhibit antioxidant activity [Shahrajabian *et al.*, 2019](#).

This work is aimed at studying the effect of this ginger extract on yoghurt produced from soy beans.

Materials and Methods

Materials

The materials that were used during the course of the study include soy bean and ginger were purchased from Oja Oba Ilorin West Local Government of Nigeria

Methodology

Preparation of aqueous ginger extract

Ginger extracts was obtained from ginger paste by modified method described by (Njoya *et al.*, 2018). Ginger root was washed, peeled and grated to form a paste. Decoction was done by boiling 100g of ginger paste in 3 L of distilled water till one fourth of the initial volume of water attained. The solution was filtered twice using a muslin cloth and allowed to sedimented for the supernatant be collected. Extracts collected was pasteurized at 75°C for 15 min, cooled at room temperature (27°C) and kept at refrigeration temperature (4°C) for further use.

Production of Soy milk

Soy yoghurt was produced using modified method of (Ranjana *et al.*, 2016). Soybean was cleaned, washed and soaked for 12 h in water at room temperature. The beans were boiled for 20 min and hulls were removed by rubbing between palm and the resulting cotyledons blended. One kg of cleaned cotyledons was blended with 5 litres of water. The resultant slurry was filtered by adding 5 litres of water through 3 layers of cheese-cloth and the residue was discarded. The filtrate was 4 litres and this was pasteurized for 30 min at 85°C and then cooled down to 45°C. After cooling, pasteurized aqueous ginger extract was added to the soymilk at different concentrations (0, 1, 3 and 5% (V/V)). Soy yoghurt was obtained by addition of commercial culture containing *Streptococcus thermophilus*, *Lactobacillus delbrueckii* spp. *bulgaricus* and *Lactobacillus acidophilus*. Starter culture (1.5 %) was added to soy milk and incubated at 43°C for 10 h and packaged then stored at room temperature for further analysis.

Physicochemical analysis of Soy yoghurt

Physicochemical analysis: The physicochemical analysis of each sample was done in triplicate. The pH and Titratable Acidity (TA) were determined according to the standard Association of Official Analytical Chemists methods (AOAC, 2005). The pH and TA determination were also done within 10 days of storage at room temperature (27°C) and at 5 days' intervals.

Sensory evaluation: Sensory evaluation of all yoghurt samples was carried out using a five-point hedonic scale with the following as categories: Excellent=5; Very Good=4; Good=3; Fair=2 and Poor=1. Colour (appearance), aroma, mouth feel, taste and overall acceptability

of yoghurt samples were evaluated by an untrained and trained panel of 16 persons between 18 and 25 years old who were regular yoghurt consumers and made of technicians and students of Kwara State University Malete, Nigeria.

Statistical Analysis

Data obtained were subjected to analysis of variance using SPSS (version 17 incorporation, by IBM SPSS, Chicago, Illinois, USA). Means of sample was separated using the Duncan multiple range test.

RESULTS AND DISCUSSION

The results of pH and titratable acidity of both yoghurt extract and yoghurt without ginger extract were recorded over a period of 10 days at room temperature are presented in Table 1. The result indicate that pH of yoghurt was affected ($P < 0.05$) by the ginger extracts over the period of storage. The pH ranges from 3.91- 4.64, this result is not consistent with those of Rashid and Takur (2012) who obtained a reduction of yoghurt pH by addition of honey. The pH values obtained were similar to the normal pH value of yoghurt which is between 4.0 and 4.1 and in accordance with the standard of ≤ 4.6 (FDA, 2009). Moreover, a significant decline ($P < 0.05$) of pH between the initial and the final values of all the yoghurt samples was observed. The significant difference between the final and the initial values of pH of all the yoghurt samples during storage was expected and could be related to the continuous fermentation of lactose into lactic acid during storage at room temperature. The higher pH recorded in spiced yoghurt in the 10th day of storage compared to unspiced indicate low level of fermentation in spiced yoghurt samples due to the antimicrobial activity of ginger extract. Ginger could thus be applied as preservative in yoghurt.

Titratable acidity ranges from 0.93-1.82%. All yoghurt samples with ginger extract presented a lower ($P < 0.05$) titratable acidity compare to the yoghurt without ginger extract (control sample). while yoghurt with ginger extract also differ significantly ($P < 0.05$) in % titratable acid. The reduction of titratable acidity of yoghurt with the increase of ginger extract concentration could be due to the preservative properties. However, there are increased in titratable acidity as the period of storage increases at all concentration of ginger extract. The titratable acidity values observed were in accordance with the normal value (0.9 – 1%) of yoghurt and the values proposed by USDA (2001), FDA (2009) and Turkish legislation (Tarakçi and Küçüköner, 2003) though it was higher than this value as the storage period increases which is an indication that even with the addition of the ginger extract yoghurt can only be stored for few days at room temperature. The titratable acidity recorded in this research were higher than the findings of Njoya *et al.*, 2018 that reported ranged of 0.9-1.01% TTA in soy yoghurt spiced with ginger extract but was contrary to those observed by Yousef *et al.*, (2013), these authors rather obtained increasing of titratable acidity with addition of fruits or honey to yoghurt. The titratable acidity of yoghurt depends mostly on the activity of lactic acid bacteria which fermented sugars into lactic acid. Thus, it depends on the availability of nutrients and water activity. The retarded increased in values of titratable acidity observed during storage in yoghurt samples with ginger extract could be explained by the inhibition of lactic acid bacteria activity due to the antimicrobial activity of ginger. The high acidity obtained in yoghurt sample without ginger extract in the 10th day compare to yoghurt samples with ginger extract at the end of storage could express a positive effect of ginger extract on the yoghurt preservation.

Table 1: Results for physiochemical properties of yoghurts at different days of storage

Samples	Storage days	pH	TTA (%)
A	0	4.46±0.00 ^c	1.04±0.04 ^h
	5	4.34±0.00 ^d	1.41±0.00 ^c
	10	4.14±0.00 ^f	1.39±0.00 ^c
B	0	4.62±0.00 ^a	1.08±0.02 ^g
	5	4.51±0.01 ^b	1.21±0.00 ^f
	10	4.20±0.0 ^c	1.32±0.01 ^d
C	0	4.64±0.00 ^a	0.93±0.01 ⁱ
	5	4.58±0.01 ^b	1.07±0.01 ^g
	10	4.41±0.01 ^c	1.26±0.01 ^e
D	0	4.31±0.01 ^d	1.24±0.00 ^{ef}
	5	4.00±0.00 ^f	1.66±0.01 ^b
	10	3.91±0.01 ^f	1.82±0.01 ^a

Values are Mean ± Standard deviation. Means with different superscript within the same column are significantly different at $p \leq 0.05$.

Key:

Sample A = 99% soymilk + 1% ginger extract

Sample B = 98% soymilk + 3% ginger extract

Sample C = 95% soymilk + 5% ginger extract

Sample D = 100% soymilk yoghurt

Sensory Properties of Soymilk yoghurt

The results of the sensory evaluation of the yoghurt sample with ginger extract and yogurt samples without ginger extract are presented in Table 2. All the samples varied significantly ($P < 0.05$). Ginger extract affected all the sensory attributes of the yoghurt, sample with 1% added ginger extract was rated high in all sensory attributes compared with 3% and 5% concentration and all the yoghurt samples with ginger extract are rated higher than control yoghurt. The result of this research is not in consistence with the findings of (Njoya *et al.*, 2018) this could be due low concentration of ginger used in this research. However, comparing the three yoghurt samples of different concentrations (1,3 and 5%) all the sensory attributes of yoghurt were rated lower with increasing ginger extract concentration. At high concentrations, ginger sensory properties could be express strongly. Therefore, it affects the original sensory properties of yoghurt by lowering its appreciation. The lowest rating acceptability recorded with the yoghurt without ginger extract can be related to soya bean unpleasant aroma soymilk.

Table 2: Results for sensory evaluation of yoghurts at different days of storage

Sample	Appearance	Taste	Aroma	Mouth feel	Overall Acceptability
A	7.3±1.58 ^a	6.47±1.91 ^a	7.23±1.17 ^a	6.57±1.61 ^a	6.73±6.73 ^a
B	6.67±1.52 ^{ab}	5.9±1.77 ^a	6.6±1.16 ^{ab}	6.17±1.51 ^{ab}	6.67±1.74 ^a
C	6.03±2.02 ^{abc}	5.53±1.93 ^{ab}	6.2±1.86 ^{bc}	5.53±1.8 ^{bc}	5.83±1.82 ^{ab}
D	5.04±1.89 ^c	4.83±2.02 ^b	5.37±1.96 ^c	4.63±1.87 ^c	5.17±2.12 ^b

Values are Mean ± Standard deviation. Means with different superscript within the same column are significantly different at $p \leq 0.05$.

Sample A = 99% soymilk + 1% ginger extract

Sample B = 97% soymilk + 3% ginger extract

Sample C = 95% soymilk + 5% ginger extract

Sample D = 100% soymilk yoghurt

Conclusion

This study revealed that incorporation of ginger extract in to soy yoghurt have significant effect on the physicochemical and sensory properties of soy yoghurt. During storage at room temperature ginger extract positively affect the change of pH and titratable acidity. Addition of ginger extract to soy yoghurt is a worthy venture as it retardsthe lactic acid bacteria activity due to the antimicrobial activity of ginger. Yoghurt with 1 % ginger extract had the highest sensory scores and was most preferred by the panelists.

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EFFECT OF FERMENTATION ON THE ANTINUTRITIONAL COMPOUNDS AND ANTIOXIDANT ACTIVITIES OF GELATINIZED BAMBARA GROUNDNUT FLOUR

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Abstract

This study investigated the effect of fermentation on the antinutritional compounds and antioxidant activities of gelatinized Bambara groundnut flour (GBGF). The GBGF was fermented at different periods (2, 4, 8, 16 and 24 h) using *Saccharomyces cerevisiae*. Gelatinization significantly ($p \leq 0.05$) reduced the level of phytic acid, oxalate, tannin, trypsin inhibitors and raffinose by 27.18%, 18.35%, 22.79%, 18.24% and 18.89%, respectively while phytochemical constituents (total phenolic content, TPC and total flavonoid content, TFC) and antioxidant activities (DPPH, FRAP and ABTS radical scavenging activity) were significantly ($p \leq 0.05$) improved compared to raw Bambara groundnut flour. Fermentation further decreased phytic acid (32.50-62.70%), oxalate (21.27-60.39%), tannin (31.94-79.84%), trypsin inhibitors (21.07-83.65%) and raffinose (31.50-70.80%). However, fermentation further improved the TPC (5.70-6.89 mg GAE/g), TFC (4.17-4.96 mg CE/g), DPPH (56.50-72.48%), FRAP (3.24-3.92 $\mu\text{mol TE/g}$) and ABTS (2.19-2.88 $\mu\text{mol TE/g}$) of the gelatinized Bambara groundnut flours. These results revealed that combined gelatinization and fermentation with *Saccharomyces cerevisiae* could serve as an effective biotechnological approach for substantial reduction of antinutritional compounds and improvement of antioxidant potential of Bambara groundnut flour.

Keywords: Bambara groundnut, Fermentation, Gelatinization, Antinutritional Compounds, Antioxidant potential

1.0 Introduction

The demand for high nutritional value-added food products has increased over the last few years throughout the world partly due to human population growth and consumer health awareness (Alroshan *et al.*, 2021). Bambara groundnut (BGN) is an underutilized, drought-tolerant African legume next to groundnut and cowpea (Chinma *et al.*, 2021). BGN contains high content of protein (17.4-30.7%) and lysine, rich in dietary fiber, micronutrients and resistant starch (Chinma *et al.*, 2021). BGN, like other legumes, contains a wide range of phytochemicals and bioactive constituents and its consumption is associated with numerous health benefits including the prevention of chronic and non-communicable diseases (Adebiyi *et al.*, 2019).

However, the utilization of BGN in the food system is limited by the presence of antinutritional factors (ANFs) which limit nutrient digestibility and have adverse toxicological effects in the human system. Several thermal processing and bioprocessing methods have

been employed to reduce the concentration of antinutrient compounds in cereals and legumes. Aside degradation of antinutrient compounds, heat treatment methods (such as autoclaving, cooking, autoclaving, roasting, extrusion, infrared, microwaving, among others) cause a total or partial starch gelatinization, enhanced emulsifying, foaming, and water retention capacity and thickening; thus, improving technological suitability of legumes flours to be used as ingredients in baked goods, snacks and pasta. Research has also established that bioprocessing techniques such as fermentation with baker's yeast (*Saccharomyces cerevisiae*) has been employed to improve the functionality of grains (Chinma *et al.*, 2020). Furthermore, the use of biotechnological approach, combining thermal treatment ("gelatinization") and fermentation has been employed to reduce antinutritional compounds, improve nutritional composition and functional properties of legume flours (De Pasquale *et al.*, 2020). Nevertheless, the effect of fermentation with baker's yeast (*Saccharomyces cerevisiae*) on the antinutritional compounds of gelatinized Bambara groundnut flour has not been investigated. It can be hypothesized that fermentation with *Saccharomyces cerevisiae* may modify the level of antinutrient compounds, phytochemical constituents, and antioxidant activities in gelatinized BGN flour for improved nutrition. The objective of this study was to evaluate the effect of fermentation time (2, 4, 8, 16, and 24 h) on the antinutrient composition and antioxidant properties of gelatinized Bambara groundnut flour.

2.0 Materials and Methods

2.1 Materials

Bambara groundnut (brown variety) seeds were purchased from an Agro seed Company based in Minna Central Market, Minna, Nigeria. Chemicals and reagents were procured from a reputable Agrochemical industry in Minna and Abuja.

2.2 Sample preparation

Cleaned BGN seeds were washed in clean tap water, drained, and dried in air draft-oven (Gallenkamp, Cheshire, UK) at 50 °C for 24 h. The dried BGN grains were milled (Globe P 44, Diamond Tools Co. Ltd. Henan, China) and sieved (mesh size of 100 µm) to produce raw Bambara groundnut flour (RBGF).

For the gelatinized flour, Bambara groundnut seeds were washed in cold tap water and thereafter soaked in cold tap water (1: 5 w/v) for about 4 h at room temperature (28 ± 1 °C), drained and the soaked seeds were steamed at 100 °C for 20 min. Afterwards, the steamed grains were oven dried at 50 °C for 24 h and milled in a hammer mill (Globe P 44, Diamond Tools Co. Ltd. Henan, China) and sieved using a mesh size of 100 µm to obtain gelatinized Bambara groundnut flour (GBGF).

For the fermented-gelatinized flour, 1 g of baker's yeast was dissolved in 100 mL of distilled water. The mixture was then added to 100 g of the flour to act as starter. The batter was fermented at 37 °C in a fermentation cabinet (National MEG Company, Lincoln, USA) at different periods (2, 4, 8, 16 and 24 h). The fermented BGN batter was dried in an oven at 50 °C for 24 h and the dried flour was blended and sieved (to pass through 100 µm screen) to produce fermented-gelatinized Bambara groundnut flour (GFBGF).

2.3 Determination of antinutritional factors

Phytic acid and tannin content were determined as previously reported by Chinma *et al.* (2021). Trypsin inhibitor activity (TIA) was measured using a trypsin substrate (0.04 g/L of BAPA,

N α -benzoyl-L-arginine 4- nitroanilide hydrochloride) following a standard procedure (Chinma *et al.*, 2021). Oxalate content was assayed according to the method described by Adebisi *et al.* (2019). Raffinose content was determined using the Raffinose/D -Galactose Assay Kit (K-RAFGA, Megazyme International, Ireland).

2.4 Determination of phytochemical constituents and antioxidant properties

The methanolic extract from BGN flour samples for the profiling of total phenolic content (TPC) and antioxidant properties was prepared according to a standard procedure (Chinma *et al.*, 2014). The TPC was determined following the Folin–Ciocalteu reagent method previously described by Chinma *et al.* (2014) and expressed as mg GAE/100 g. The total flavonoids content (TFC) was determined according to the method of Bao *et al.* (2005) and presented as mg CE/g. The DPPH (1,1-diphenyl-2-picryl-hydrazil) radical scavenging activity and ferric reducing antioxidant power (FRAP) were determined as described by Chinma *et al.* (2014) while ABTS (2,2'-Azino-bis-3-ethylbenzthiazoline-6-sulfonic acid) was determined according to a standard procedure (Sant'Anna *et al.*, 2016).

2.5 Statistical analysis

Data obtained were subjected to analysis of variance using a statistical software (SPSS 20, BM, Armonk, NY, USA) while Tukey's test was used to determine significant differences (5% probability) among means.

3. Results and Discussion

3.1 Antinutritional composition of raw, gelatinized, and gelatinized-fermented BGN flours

The antinutritional composition of raw, gelatinized and gelatinized-fermented Bambara groundnut flour samples are presented in Table 1. The raw BGN flour contained 5.63 mg/100 g phytic acid, 7.90 mg/100g oxalate, 6.45 mg/100g tannin, 3.18 TIU/mg and 1.27 mg/100 g raffinose; which is in close to the values (except raffinose) reported for raw BGN by other researchers (Adebisi *et al.*, 2019; Chinma *et al.*, 2021). Compared to raw BGN, the concentration of antinutrient compounds (phytic acid, oxalate, tannin and raffinose) were reduced significantly in gelatinized BGN flours probably due to leaching-out of the antinutrients during soaking or boiling to aid gelatinization or due to thermal gradient that occurred during the first step of the gelatinization process which induced the activation of endogenous enzymes that degraded antinutrients including raffinose (De Pasquale *et al.*, 2020). It was also observed that higher reductions in antinutritional factors (ANFs) were recorded following fermentation of gelatinized BGN flours compared to raw BGN, partly due to increased activity of lactic acid bacteria in reducing ANFs following fermentation.

3.2 Antioxidant potential of raw, gelatinized, and gelatinized-fermented BGN flours

The TPC and TFC of the raw BGN samples were 5.43 GAE mg/100 g and 3.67 mg CE/g, respectively, which is in close range with the values previously reported for raw BGN (Adebisi *et al.*, 2019). The TPC and TFC of the gelatinized samples were significantly higher than the control (Table 2) probably due to release of conjugated phenolic compounds upon disruption of complex structures during hydrothermal treatment (Nickel *et al.*, 2016). It was also observed that higher reductions of phytochemical constituents were recorded in fermented-gelatinized BGN samples; which also increased ($p \leq 0.05$) with fermentation time (2-24 h). The observed increase may be attributed to the release of bound components by microbial enzymes during

fermentation as well as formation of Maillard reaction products with phenol and reductone-type structures caused by partial destruction of cellular structure during thermal treatment (Zou *et al.*, 2018). Consequently, higher antioxidant activities were recorded in fermented-gelatinized BGF samples followed by gelatinized BGF samples and raw BGF; which corroborates that high phytochemical constituents are associated with high antioxidant activities (evaluated in terms of DPPH, FRAP and ABTS in this study). From this perspective, the antioxidant activities of the samples were in the order: FGBGF > GBGF > RBGF. These results contradicts the findings of De Pasquale *et al.* (2020) who reported higher antioxidant activities in raw legume (red lentil, yellow lentil, white beans, black beans, and chickpea) flours than lactic acid fermented-gelatinized, and gelatinized samples; thus, ascribed to the effect of thermal treatment that caused significant reduction of the total phenols due to polymerization.

Conclusions

This study demonstrated that gelatinization, and combined fermentation and gelatinization caused significant reduction in antinutrient compounds while phytochemical constituents and antioxidant activities of Bambara groundnut flours were improved. Consequently, the low level of residual antinutrients in BGN after gelatinization, and combined gelatinization and fermentation is expected to improve the nutritional properties of the flour for food fortification. However, research is on-going in our laboratory on the impact of fermentation on the nutritional composition and techno-functional properties of gelatinized Bambara flours for food product development.

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Table 1. Effect of fermentation time on the antinutritional properties of gelatinized Bambara groundnut flour

Parameters	Raw flour	Gelatinized flour	2-hFGF	4-hFGF	8-h FGF	16-hFGF	24-hFGF
Phytic acid (mg/ 100g)	5.63±0.02 ^a	4.10±0.01 ^b	3.80 ± 0.01 ^c	3.06±0.01 ^d	2.77 ± 0.02 ^e	2.42± 0.01 ^f	2.05± 0.01 ^g
Phytic acid reduction (%)	-	27.18	32.50	27.88	33.04	46.36	62.70
Oxalate	7.90±0.02 ^a	6.45±0.02 ^b	6.22± 0.01 ^c	5.40±0.01 ^d	4.91± 0.01 ^e	4.45± 0.01 ^f	3.13±0.03 ^g
Oxalate reduction (%)	-	18.35	21.27	31.64	37.85	43.67	60.39
Tannin (g/kg)	6.45±0.01 ^a	4.98± 0.02 ^b	4.39±0.01 ^c	4.05±0.01 ^d	3.80±0.03 ^e	2.52± 0.02 ^f	1.30±0.02 ^g
Tannin reduction (%)	-	22.79	31.94	37.21	41.09	60.93	79.84
TIA/TIU/ mg	3.18±0.03 ^a	2.60±0.01 ^b	2.51 ± 0.02 ^c	2.23 ±0.03 ^d	1.74±0.02 ^e	1.06±0.01 ^f	0.52±0.01 ^g
TIA reduction (%)	-	18.24	21.07	29.85	45.28	66.67	83.65
Raffinose (g/100 g)	1.27± 0.01 ^a	1.03± 0.01 ^b	0.87±0.00 ^c	0.75± 0.01 ^d	0.62±0.01 ^e	0.50±0.01 ^f	0.38±0.01 ^g
Raffinose reduction (%)	-	18.89	31.50	40.94	51.18	60.62	70.08

Data presented as means ± standard deviation from triplicate analysis. Means with no common letters within a row are significantly different at ($p \leq 0.05$).

TIA = Trypsin inhibitor activity; 2-hFGF = 2-h fermented and gelatinized flour, 4-hFGF = 4-h fermented and gelatinized flour, 8-hFGF = 8-h fermented and gelatinized flour, 16-hFGF = 16-h fermented and gelatinized flour and 24-hFGF = 24-h fermented and gelatinized flour

Table 2. Effect of fermentation time on the antioxidant properties of gelatinized Bambara groundnut flour

Parameters	Raw flour	Gelatinized flour	2-hFGF	4-hFGF	8-h FGF	16-hFGF	24-hFGF
Total phenolic content (mg GAE/ g)	5.43±0.03 ^a	5.70±0.02 ^a	5.98 ± 0.01 ^a	6.24±0.02 ^a	6.47 ± 0.03 ^a	6.65± 0.01 ^b	6.89± 0.02 ^b
Total flavonoid content (mg CE/g)	3.67±0.01 ^a	3.89±0.01 ^a	4.17 ± 0.02 ^a	4.39±0.01 ^a	4.53 ± 0.00 ^a	4.70± 0.01 ^b	4.96 ± 0.03 ^b
DPPH (%)	44.51±0.19 ^a	50.22±0.14 ^a	56.50 ± 0.16 ^a	57.06±0.11 ^a	59.15 ± 0.16 ^a	65.29± 0.14 ^b	72.48 ± 0.20 ^b
FRAP (μmol TE/g)	2.84±0.01 ^a	3.06±0.02 ^a	3.24± 0.02 ^a	3.38±0.01 ^a	3.57± 0.01 ^a	3.74± 0.01 ^b	3.92± 0.01 ^b
ABTS (μmol TE/g)	1.65±0.02 ^a	1.93±0.01 ^a	2.19± 0.01 ^a	2.25±0.01 ^a	2.49 ± 0.00 ^a	2.65± ± 0.01 ^b	2.88 ± 0.01 ^b

Data presented as means ± standard deviation from triplicate analysis. Means with no common letters within a row are significantly different at ($p \leq 0.05$).

DPPH: 2,2-diphenyl-1-picrylhydrazyl; FRAP: Ferric reducing anti-oxidant power and ABTS= 2,2'-Azino-bis-3-ethylbenzthiazoline-6-sulfonic acid.

2-hFGF = 2-h fermented and gelatinized flour, 4-hFGF = 4-h fermented and gelatinized flour, 8-hFGF = 8-h fermented and gelatinized flour, 16-hFGF = 16-h fermented and gelatinized flour and 24-hFGF = 24-h fermented and gelatinized flour

CHAPTER 4

ROOTS AND TUBER PROCESSING

EVALUATION OF FUNCTIONAL AND PROXIMATE COMPOSITION OF FLOUR, STARCH, FLOUR RESIDUE AND FERMENTED FLOUR FROM SWEET POTATO.

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Abstract

The functional and proximate composition of sweet potato (flour, starch, fermented flour and residue). The sweet potatoes were washed, peeled, sliced, dried and milled to flour. The starch, residue and were also produced from the sweet potato. The functional and proximate of the flours were determined. The GENSTAT Statistical Software (version 17.0) was used for data analyses. The Data obtained showed the following ranges for bulk density (0.63-0.93 g/ml), water absorption capacity (2.23-5.41 g/g), oil absorption capacity (1.38-2.25 g/g), gelation capacity (8.91-18.80 %), swelling index (3.17-8.93), emulsification capacity (11.93-19.27) and pH (3.37-6.00). The result of the proximate compositions of the flours ranges for moisture (7.00-8.26 %), protein (1.87-5.51 %), fat (0.11-1.16 %) fibre (1.22-5.06 %) ash (0.64-1.83 %), carbohydrates (74.20-88.03 %), total starch (7.76-37.12 %), amylose (8.77-19.34 %) and amylopectin (80.68-93.98 %). The products from sweet potato(SP), such as the starch, flour, residue and fermented flour are important for application in baked food production, if successful, has the potential of providing a varied end use for the crop while taking advantage of its high nutritional value and also curbing post-harvest losses. The result obtained in this study indicate that sweet potato is an excellent source of composite flour with unique functional properties which could be of beneficial to the bakery industries and help in reducing the importation of wheat flour into Nigeria.

Keywords: post-harvest losses, nutritional value, carbohydrate, protein, bulk density

Introduction

Sweet potato (*Ipomeabatatas*) is a tuber of the herbaceous climbing plant known in Britain much earlier than the Irish potato. The flesh may be white, yellow or pink (if carotene is present) and its leaves are also edible; Sweet potato is another of the world's most important food crops and an important staple in Nigeria and other developing countries (Odebode *et al.*, 2008). It is a low input crop and is used as vegetable, a desert, a source of starch and animal feed (Odebode *et al.*, 2008).

In Nigeria, sweet potato is mostly consumed as a snack (*asondo*), roasted, boiled, used with fresh yams in pounded yam and as a sweetener in beverage production. Processing sweet potato into flour would increase its utilization and can serve as a source of (carbohydrates, vitamin C, vitamin B6) minerals calcium, phosphorus, iron, potassium, magnesium and zinc, flavor and dietary fibre of processed food products such as bread and also useful in other food preparations (Ofori *et al.*, 2009).

Composite flour is a mixture of flours such as cassava, yam, potato, and protein-rich flour and cereals, with or without wheat flour that is created to satisfy specific functional characteristics and nutrient composition, for example; wheat with sweet potatoes (Edun *et*

al., 2019). As an innovative flour composite flour has attracted much attention in research as well as food product development (Hasmadi *et al.*, 2014).

Thus, composite flour became the subject of numerous studies. There has been increasing interest in replacing conventional gluten-free formulations made from refined gluten-free flour, starch, and hydrocolloids with those enriched with functional gluten-free ingredients (Alvarez- Jubete *et al.*, 2010). The aim of this study was to determine the functional and proximate properties of flour, starch, flour residue and fermented flour from sweet potato roots.

Materials and Methods

Source of Materials

Sweet potato, SP (*Ipomea batatas*), was purchased from Kaura Namod Central Market. Packaging material: Johnson's polyethylene ziplock double zipper storage bags (26.8 x 27.3 cm; 17.7 x 19.5 cm) were purchased from the Abubakar Gumi Central Market, Kaduna. All laboratory materials and reagents used were of analytical grade. The raw materials were properly cleaned by removing extraneous matter prior to their subjection to different processing treatments.

Sample Preparations

Production of sweet potato (SP) flour

Sweet potato (SP) flour was produced according to the method described by Avula (2005), with modification. The tubers were washed and peeled manually with knives, and kept in water to prevent enzymatic browning. The tubers were manually trimmed and sliced thinly and oven dried at 60°C, milled, sieved (0.5mm), packaged in polyethylene bag and labeled accordingly.

Production of (SP) Sweet potato starch and flour residue

Starch was prepared from sweet potato roots according to the method described by Avula *et al.* (2005), with modification. Roots were cleaned under running tap water, then manually peeled and milled in a food processor (MK-5080, National, Malaysia) by adding 1:1 (w/w) of clean water ratio for 2 min at medium speed. After filtering through sieve, the residue was subjected to repeated extraction with water (1:0.5, w/w). The filtrate was mixed and filtered through muslin cloth. Starch slurry was allowed to settle for 2-3 hours at room temperature (30±2°C). The supernatant was poured off. The starch in the bottom of container was re-suspended in water, filtered through cloth bag and kept in the refrigerator (8±1°C) to settle. The settling process was repeated three times. The sediment starch was dried in a convection oven at 50 °C for 6 h, cooled to room temperature, packed and sealed in polyethylene bags. Non-starch residue pulled together from the filtering processes was oven dried at 60°C for 7 h, cooled to room temperature, packaged, and labeled accordingly. Dried starch and non-starch residue were milled, sieved, packaged and refrigerated prior to use.

Production of Fermented Sweet Potato Flour

Sweet potato (SP) flour was produced according to the method of Avula (2005), with modification. The tubers were washed and peeled manually with knives, keeping them in water to prevent enzymatic browning. The tubers were trimmed and sliced thinly (manually) and soaked in water to ferment for the period of 12 hrs drained and oven dried at 60°C, milled, sieved (0.5mm), packaged in polyethylene bag and labeled accordingly.

Determination of the Functional Properties and Proximate Composition of the Flours from Sweet Potato

The functional properties (bulk density, water and oil absorption capacity, gelation capacity, swelling index, emulsification capacity and pH) of the flours from sweet potato were determined according to the methods described by Onwuka (2018). The proximate composition of the flours from sweet potato were determined according to the methods described by AOAC (2012) and Carbohydrate content was determined by difference according to the method described by Onwuka (2018).

Statistical Analysis

Data generated from the respective analyses were compiled appropriately and subjected to Analysis of Variance. Mean separation for sensory results was done using the Fischer's least significance difference test. All other data had the means separated using the Duncan Multiple Range test (GENSTAT Statistical package, version 17.0).

Results and Discussion

Table 1. Functional Properties of Flour Blends

Sa mpl e	Bulk Density (g/ml)	WAC (g/g)	OAC (g/g)	Gelation Capacity (%)	Swelling index	Emulsificati on Capacity (%)	pH
A	0.64 ^a ±0.01	1.33 ^a ±0.03	1.70 ^b ±0.01	8.77 ^b ±0.04	2.17 ^a ±0.06	14.21 ^b ±5.62	5.14 ^c ±0.07
B	0.83 ^d ±0.00	1.36 ^a ±0.04	1.38 ^a ±0.02	12.01 ^d ±0.02	7.93 ^d ±0.00	16.14 ^d ±0.01	4.37 ^a ±0.06
C	0.69 ^b ±0.02	1.32 ^a ±0.01	1.83 ^d ±0.01	8.94 ^a ±0.07	2.39 ^b ±0.04	11.93 ^a ±0.01	5.32 ^d ±0.01
D	0.86 ^c ±0.00	1.41 ^b ±0.01	2.02 ^c ±0.01	10.70 ^c ±0.01	6.22 ^c ±0.01	14.27 ^c ±0.06	6.00 ^b ±0.00
LS D	0.01	1.04	0.07	0.56	0.08	1.45	0.33

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly (p<0.05).

Key: WAC= water absorption capacity

OAC= oil absorption capacity

A= Sweet potato flour.

B= Sweet potato Starch.

C= Sweet potato Residue

D= Fermented sweet potato flour.

LSD= Least significant difference

Table 2: Proximate Composition of Flour, starch, sweet potato Residue and fermented Flour

Sample	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
A	7.20 ^a ±0.09	1.87 ^a ±0.06	0.93 ^a ±0.01	1.35 ^b ±0.02	0.64 ^a ±0.04	88.03 ^a ±0.01
B	7.00 ^a ±0.03	1.87 ^a ±0.01	0.11 ^b ±0.02	1.22 ^a ±0.01	2.15 ^b ±0.02	87.65 ^b ±0.00
C	7.56 ^a ±0.37	2.16 ^a ±0.04	0.83 ^c ±0.01	1.32 ^b ±0.01	0.95 ^c ±0.02	87.18 ^c ±0.42
D	8.26 ^b ±0.05	5.51 ^b ±0.01	1.16 ^d ±0.04	5.06 ^c ±0.05	1.83 ^d ±0.01	78.18 ^d ±0.01
LSD	0.78	1.22	0.03	0.08	0.02	0.12

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key: A= Sweet potato flour.

B= Sweet potato Starch.

C= Sweet potato Residue

D= Fermented sweet potato flour.

LSD= Least significant difference.

Tabel 1 shows the functional properties of flour, starch, residue and fermented flour from sweet potato. Bulk density of flour is used to evaluate the flour heaviness, handling requirement and the type of packaging materials suitable for storage and transportation of food materials. The flour of the sweet potato (A) had the lowest bulk density (0.64 g/ml) and the highest (0.86 g/ml) was recorded in the sweet potato starch (B). Similar range of bulk density values (0.60-0.85 g/ml) have been reported by Ndife *et al.* (2014) in flours.

Water absorption capacity is the ability of product to incorporate water and water inhibition is an important functional trait in food such as sausages, custard and dough (Ojo *et al.*, 2017). The fermented sweet potato flour recorded significant ($p < 0.05$) highest water absorption capacity than other flour samples. The sweet potato flour (A), starch (B) and sweet potato residue (C) were low in water absorption capacities.

The results of the oil absorption capacity of flour samples showed that sample D was significantly ($p < 0.05$) higher than other flour samples and the least was recorded in sample B. The high oil absorption capacity in sample D could be attributed to its flour protein content.

Gelation capacity measures the amount of flour needed to form a gel in a measured volume of water. The sweet potato starch (B) was significantly higher than other flour samples. The (SP) flour, and residue were low in their gelling ability. Swelling index is a function of loose particles (Awolu *et al.*, 2017). There were significant differences ($p < 0.05$) in the swelling power among the flours (A, B, C) and (D) flour. The swelling index of the sample B and D are high compare to sample A and C.

The emulsion capacity of the various flour showed that the residue flour of sweet potato (C) was significantly ($p < 0.05$) lower than other samples and the highest was recorded in the starch (B).

The pH of the flour of samples were not significantly ($p > 0.05$) different from each other, highest value was recorded in sample (D) while the lowest in sample (B).

Table 2 show the proximate compositions of flour, starch, residue and fermented flour from sweet potato. The range of moisture contents (7.00 -8.26 %) of the flour samples of sweet potato flour, starch, residue and fermented flour is reasonably comparable to the moisture content of flours reported by Rodrigues *et al.* (2016).

The protein contents of the flour samples showed that sample (D) was significantly ($p < 0.05$) higher than other flour samples but the least value was recorded in sample (A and B) flour. The fat contents of the flours of sweet potato flour, starch, residue and fermented flour were lower which are similar with the findings of Rodrigues *et al.* (2016)

The flour of showed higher crude fibre contents than the flour of fermented sweet potato. This trend could be attributed to the higher and lower crude fibre contents of sweet potato respectively.

The ash content of the sweet potato flour was lower than all other flour samples and significantly ($p > 0.05$) differ from the flours. The result of the carbohydrate contents of the flours showed that the sweet potato flour, starch and residue flour had highest content. This was followed by fermented flours of sweet potato.

Conclusion

Sweet potato root was processed into flour, starch, residue and fermented flour. The bulk density, gelation capacity, emulsion capacity and pH of the flours of sweet potato, starch, starch, residue and fermented compared favorably. The fermented flours recorded higher moisture contents than the other flour counterparts. Sweet potato flours processing will reduce food shortages, contribute to income generation and employment generation; The flours has the potential of providing a varied end use for the crop and also curbing post-harvest losses.

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PROXIMATE AND CYANIDE COMPOSITIONS OF WHITE AND YELLOW GARRI IN LAGOS STATE

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ABSTRACT

Five samples of white garri namely: White garri from Ikeja (WGIK), White Garri from Ajah (WGAJ), White Garri from Agege (WGAG), White garri from Onipanu (WGON), White garri from Oyingbo (WGOY) and three samples of yellow garri samples namely: Yellow garri from Ikeja (YGIK), Yellow garri from Yaba (YGYA) and Yellow garri from Badagri (YGBA) were investigated for their proximate, starch and cyanide compositions. The moisture contents ranged between 4.53 ± 0.00 and 16.75 ± 0.00 . The ash contents ranged between 1.54 ± 0.00 (WGON) to 2.06 ± 0.00 (WGIK). The crude fibre values were between 1.98 ± 0.01 (WGIK) and 3.58 ± 0.00 (WGAG). The protein values were between 0.82 (YGBA) and 1.09 (YGYA). The carbohydrate contents were between 75.81 ± 0.00 and 93.87 ± 0.28 (WGIK). The white garri samples had higher carbohydrate contents than the white samples. This was corroborated by the energy value which ranged from 329.29 ± 1.14 (YGYA) and 382 ± 2.28 (WGIK). The starch contents were between 51.39 ± 0.14 (WGOY) and 64.04 ± 2.28 (WGIK). The cyanide contents ranged between 4.23 ± 0.00 (WGIK) and 4.73 ± 0.00 (WGON). The hydrogen cyanide contents were between 4.23 ± 0.00 (WGIK) and 4.73 ± 0.00 (WGOY). The total acidity ranged between 0.03 ± 0.00 (YGIK and YGYA) and 0.22 ± 0.01 (WGOY). The aims of this research are to determine the proximate and cyanide compositions of white and yellow garri samples; and to know their health implications if consumed. Further studies will look into other nutritional and antinutritional properties of these garri samples.

Keywords: Proximate, Cyanide, Starch, Garri, Permissible

INTRODUCTION

Garri is the creamy granular flour obtained by traditional or industrial processing of cassava roots by processing the starchy tuberous roots of freshly harvested cassava (*manihot utilisima*, *esculenta* and or *palmate*) or other *manihot* species (African foods, 2015). The root processing (unit operation) consists of peeling, washing and grating of the roots followed by fermentation, pressing, breaking of the cake, sifting and partial degradation of the cassava cake and then final drying. It is a major staple food in the developing world, providing a basic diet for over half a billion people (FAO, 1995; Dzedzoave, 2008)). In Nigeria, garri is widely acceptable and consumed by both the poor, the middle men or average Nigerian and also the rich because it serves as a major source of carbohydrate. Garri can be taken in various forms; some people use it to make eba or soak inside water

along with groundnut, mashed beans, or bean cake (akara). The major problem of consuming garri is the toxicity which may arise from poor processing of cassava which is rich in cyanogenic glucosides. Consumption of cyanide and its accumulation in human body normally lead to neurological disorders and goiter (Ojo and Akande, 2013). Cyanide has been found to be greatly reduced during the processing of cassava to garri. Unit operations have been found to effectively reduce the residual cyanide contents of the product (Ojo and Akande, 2013). The traditional method of garri production which requires the cassava slurry to be fermented for 72 h during which the cyanides (linamarin and lotaustralin) are hydrolyzed by linamarase enzyme to yield hydrocyanic acid which has low boiling point and easily escape during roasting render the garri safe for consumption (Chijioke et. al., 2010). Garri contains proteins, fat, carbohydrates, iron, vitamin B and C and also starch. In West Africa, there are two types of garri, white and yellow garri. Yellow garri is prepared by adding palm oil just before the fermenting stage of the cassava mash. Alternatively, it can be made using the yellow-fleshed breed of cassava. White garri on the other hand is fried without addition of palm oil (Wisebaker, 2021). Little has been done on the compositional difference between white and yellow garri. This study was aimed at evaluating the proximate analysis of the different (white and yellow) garri samples.

Materials and Method

Eight samples of white and yellow garri were purchased from seven different markets in seven different locations (Ikeja, Ajah, Agege, Onipanu, Oyingbo and Badagry) in Lagos State into newly bought, thoroughly washed and dried containers. The containers were covered and labeled. Moisture, Ash, Crude Fibre, Protein and Fat Content were carried out in accordance with the method of AOAC (2016). Carbohydrate content was determined by estimation using the following equation:

Carbohydrate (%) = 100- {Moisture (%) + Protein (%) + Fat (%) + Ash (%) + Crude fibre (%)}

Energy value was expressed by:

(% Carbohydrates x 4) + (% Fat x 9) + (% Protein x 4).

Starch was determined using Lane and Eynon method, Pearson, (1991). Cyanide was determined using AOAC, (2005) and total acidity was also determined using AOAC, (2016).

Results and Discussion

Table 1.0: Proximate Composition of White and Yellow Garri

Parameters	Unit	WGIK	WGAJ	WGON	WGOY	WGAG	YGIK	YGYA	YGBA
STD									
Moisture	%	4.83±	5.11±	8.62±	4.53±	7.76±	14.20±	16.75±	15.45±
		0.00	0.01	0.02	0.00	0.01	0.02	0.00	0.02
Ash	%	2.06±	1.16±	1.54±	1.45±	1.48±	1.17±	0.79±	1.22±
		0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
Fat	%	1.01±	0.33±	0.68±	0.90±	0.79±	2.39±	2.41±	2.56±
		0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00
Crude fibre	%	1.98±	3.24±	2.32±	2.22±	3.58±	2.98±	3.15±	3.08±
		0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.01
Protein	%	0.99±	1.05±	0.92±	0.87±	0.98±	0.87±	1.09±	0.82±
		0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.00
CHO	%	93.87±	92.65±	85.92±	90.30±	85.41±	78.39±	75.81±	76.87±
		0.28	0.14	2.28	0.14	0.14	0.28	0.00	2.28
E. value	Kcal	382.79±	376.97±	353.48±	371.70±	353.43±	338.55±	329.29±	333.80±
		2.28	2.28	1.14	2.28	2.28	1.14	1.14	1.14
Starch	%	64.04±	60.82±	54.26±	51.39±	61.00±	61.98±	63.13±	62.86±
		2.28	1.14	0.00	0.14	2.28	0.00	1.14	0.00
Cyanide	mg/kg	4.23±	4.40±	4.42±	4.73±	4.63±	4.46±	4.59±	4.48±
		0.00	0.01	0.01	0.00	0.02	0.01	0.00	0.00
Total Acidity		0.13	0.10	0.16	0.22	0.05	0.03	0.00	0.06
(As lactic acid)		0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00

Key: WGIK = White garri from Ikeja, WGAJ = White garri from Ajah, WGAG = White garri from Agege, WGON = White garri from Onipanu, WGOY = White garri from Oyingbo, YGIK = Yellow garri from Ikeja, YGYA = Yellow garri from Yaba and YGBA = Yellow garri from Badagri

The moisture contents of all the yellow garri samples were far above the permissible level by standard organization of Nigeria (SON), WGON and WGAG moisture contents were slightly higher than the permissible level while the moisture contents of WGIK, WGAJ and WGOY fell within the permissible. Hence, yellow garri samples should not be kept for so long because of its higher moisture content to avoid caking, contamination and deterioration. The ash contents of the samples ranged between 0.79 ± 0.00 and $2.06 \pm 0.00\%$. Only WGIK was significantly higher than 1.5 recommended by SON. An increase in ash content up to 0.5% is an indication of an increase in the mineral content of the sample (Adeleke and Odedeji, 2010). The fat contents ranged between 0.33 ± 0.00 to 2.56 ± 0.00 , with the yellow garri samples having higher fat contents than the white garri samples. This may be due to the palm oil added to them during processing. The white garri samples with low fat content will not undergo rancidity during storage and could be stored for a longer period without any discoloration or development of off-odour than the yellow garri. Therefore, for a low fat diet white garri is recommended while for a high fat diet yellow garri is recommended. The crude fibre values ranged between 1.98 ± 0.01 and 3.58 ± 0.00 with WGAG having the highest and WGIK having the least. Only WGIK had crude fibre

slightly below SON standard, WGON and WGOY crude fibre were slightly above while others were significantly higher than the SON standard. Crude fibre has been reported to aid digestion through peristalsis bowel movement (Castellenos et. al, 2004). This therefore indicates that white and yellow garri will be easily digested if consumed and will not cause constipation. The protein contents are between 0.82 ± 0.00 in YGBA and 1.09 ± 0.02 in YGYA. The carbohydrate contents of the samples are between 75.81 ± 0.00 in YGYA and 93.87 ± 0.28 in WGIK. The carbohydrate contents of the white garri samples ranged between 85 and 93% while it is between 75 and 78% in yellow garri. Generally, the white garri has more carbohydrate than the yellow garri. This difference could be due to the addition of palm oil to the yellow garri samples. The carbohydrate content is further corroborated by their energy values, the white garri samples have higher energy value than the yellow garri samples. The starch contents of the samples ranged between 51.39 ± 0.28 in WGOY and 64.04 ± 0.14 in WGIK

The hydrogen cyanide (HCN) values were far below the recommended value by SON and are safe for consumption. However, long-term consumption of garri containing low levels of HCN produces goiter and neuropathy and 50 mg of cyanide per 50 kg body weight could be lethal to man (Nartey, 2001). This implies that an average person of 70 kg body weight will have to consume between about 53 to 1944 kg dry garri flour before the lethal effects of cyanide poisoning will set in

The total acidity ranged between 0.03 ± 0.00 (YGIK and YGYA) and 0.22 ± 0.01 (WGOY). Their acidities were far below the permissible level given by SON. This implies that both white and yellow garri are safe for consumption without fear of acidosis or any diseases associated with excess acid in the food.

Conclusion

Garri is a staple food in Nigeria with a lot of nutrition benefits. Both the white and yellow garri are good for consumption with a lot of nutritional and health benefits as well as few side effects if not properly produced. The choice of consumption should be based on the nutritional requirements of the individual consuming it. Yellow garri has higher tendency of caking, contamination, deterioration and discolouration because of its high moisture content and fat content, hence it should not be kept for so long. Both yellow and white garri samples aid digestion due to their high fibre content. However, in producing garri, cassava should be made to pass through the normal and right stages of production in order to remove the harmful chemicals such as cyanide.

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PROXIMATE AND ANTI-NUTRIENT PROPERTIES OF VENDED ANIGA AND MBUGURU FOOD DELICACIES: ROOTS AND TUBER BASED TRADITIONAL FOOD PRODUCTS

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ABSTRACT

This study determined the proximate and anti-nutrient properties of vended “Aniga” and “Mbuguru” produced from fresh mashes of water yam and cocoyam for “Aniga” and only water yam mash for “Mbuguru” and these were compared with similar properties of water yam flours. There were significant ($P < 0.05$) differences in the values obtained. The mean crude protein, ash and fat contents were of higher concentration in “Aniga” with the values 6.22%, 5.10%, 4.37% respectively than in “Mbuguru” whose respective values were 5.69%, 3.90% and 3.04%. However, the protein content of water yam flours was 7.51%. There were no significant differences in the energy values of samples. There were also significant differences in the anti-nutrient properties of the individual anti-nutrients. “Aniga” had high oxalate, and cyanide with values of 23.46 and 60.26 mg/100g respectively than the respective 13.58 and 50.61mg/100g for “Mbuguru”. The water yam flour had highest values in saponins, alkaloids, phytates and tannins. Increased production of “Aniga” and “Mbuguru” is recommended because of their high energy values and, to enhance the consumption of traditional foods.

Keywords: Aniga, mbuguru, traditional food products

INTRODUCTION

In the “Igbo Traditional Food System: Documentation, Uses and Research Needs” Okekeet *al.*, (2008), documented up to 294 species and over 400 varieties of food items. About 21 starchy roots, tubers and fruits were documented, among which yams, cocoyams, local legumes *e.t.c.*, were all of which still require much research. As at now, there is dearth of information concerning tradition or industrial food products based on these natural plant foods in Nigeria. The scientific names of these plants have not even been identified (as Okekeet *al.*, 2008) also agreed to. The result is that information on unidentified or wrongly identified crops are often neglected. Nigeria accounts for about 70% of the global production of yam, generating a global annual output of over 33million metric tons, (FAO, 2000). Among the most commonly cultivated yam species are *Dioscorea rotundata* (white yam), *Dioscorea cayenensis* (yellow yam), *Dioscorea alata* (water yam), *Dioscorea dumetorum* (Trifoliate yam), *Dioscorea bulbifera* (Ariel yam) and *Dioscorea esculenta* (Lesser yam or Chinese yam). *Dioscorea alata* is least utilized for major yam based food products, so it is more to the reach of the poorer masses. It is popular and prevalent in Abakaliki agro-ecological zone of Ebonyi State, (Oselebe and Okporie (2008). *D. alata* is an important tuber crop and staple food for people in many tropical and subtropical countries. They serve as cash crops, produce edible starchy storage tubers, are cultural and are of nutritional importance in the tropical and subtropical regions of the world, (Egesiet *al* (2005); (Oselebe and Okporie (2008). Their local Igbo names include “Jiodo”, “Jimbana”, “Jimbala”, “jimbuna” or

“jinvula”. They are consumed boiled, roasted, fried, or pounded into “fufu”. Because they are of low glycemic index, they are often considered the choice yam specie for the diabetics. *D. alata* tubers are of importance in the production of certain delicacies in the South Eastern region of Nigeria. The peeled tubers are grated into mash and used alone or in combination with grated *tannia*; *Xanthosoma spp* cocoyam mash to produce such food products as “akarajiodo” (deep oil fried water yam mash), “Mbuguru” (overnight boiled water yam mash with or without the inclusion of cocoyam leaves), “Ekpankwukwu”, (boiled water yam mash mixed with leafy vegetables, spices and some sea products) and, “Aniga” (a mixture of water yam and *tannia* mashes). The equivalent of fried water yam mash (“akarajiodo”) is “Ikokore” in Yoruba.

“Aniga” is a food product highly cherished by the people of Orumba North L.G.A, especially people in the vicinity of Oko and Ekwulobia, in Anambra State of Nigeria. Similarly, the people of Orumba South L.G.A, particularly the people in the vicinity of Umunze also in Anambra State of Nigeria, highly cherish “Mbuguru” food product. *Xanthosoma spp* (*tannia*) is reported to have great nutritional potential, but its utility is often impaired because of the presence of calcium oxalate. This oxalate, adversely affects the corm palatability (Owu-Darko *et al.*, 2014; Sefa-Dedeh and Agyir-Sackey, 2004). As an anti-nutrient, calcium oxalate represents a health hazard for humans when consumed either raw, undercooked or in high concentrations.

However, cooking removes or reduces the effect of oxalates, (Ihekoronye and Ngoddy, 1985). Despite the interest in these food products, published data on their production and the nutrient composition of these traditional foods is non-existing. As part of the efforts to boost food security in the country through promoting traditional food processing, this study was undertaken to ascertain the nutrient potentials of vended “Aniga” and “Mbuguru” produced from water yam.

MATERIALS AND METHODS

Sample collection

3kg of healthy *D. alata* tubers was procured from Eke Oko Market in Oko community, Orumba North L.G.A, Anambra State for use in the production of both “Mbuguru” and “Aniga”.

The different regular producers were supervised by the researcher to ensure the application of necessary Good Manufacturing Practice (GMP) especially in the area of use of stainless steel wares, potable water and general cleanliness.

Production of the food products

The water-yam tubers were scrubbed (under water in a stainless basin), thoroughly cleaned, air-dried, peeled and weighed. “Aniga” and “Mbuguru” were produced differently as follows:

1kg of peeled water yam tubers was grated into a stainless steel bowl for “Aniga” while 800g *tannia* and 400g water yam (ratio of 2:1 for *tannia* and water yam) were grated into another stainless steel bowl and both were whisked. The whisked mashes were wrapped with wilted cleaned plantain leaves, and cooked overnight, then cooled. The cooled products were codded “Ang” for “Aniga” and “Mbu” for “Mbuguru”. A fraction of the water yam tuber was peeled, sliced. Finally, the three materials: “Ang”, “Mbu” and

water yam slices were dried separately and milled separately into flours. The water yam flour was coded WYF. The flow chart will explain further.

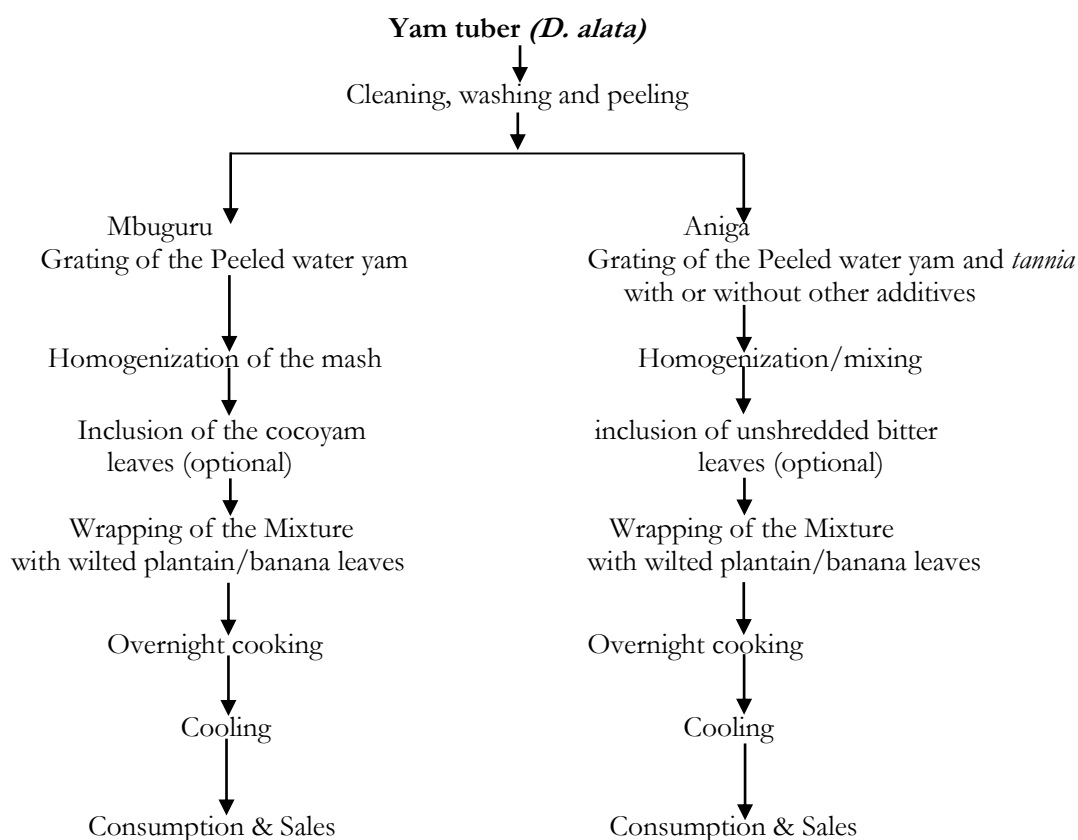


Fig 1. A: Production of the “Aniga” and “Mbuguru” food products.
Both products are usually dipped in palm oil gravy, “ogiri” or “ncha”(a palm oil in water emulsion) sauce and then consumed



Fig. 1B: Pictures of “Aniga” and “Mbuguru” food products and “ncha” sauce

Analysis of the products

The proximate composition was determined using AOAC (2010) standard methods. Energy values were calculated using Atwater general factor as follows: Energy value = 4(% protein + % carbohydrate) + 9(% crude fat) Kcal/100g, (Akinwande *et al.*, (2020).

Anti-nutrients' determination

Determination of saponins: The saponins content were determined by gravimetric method as described by Kaure *et al.*, (2015). Determination of alkaloid: The alkaloids were determined by slightly modified method as described by Biradar and Racheti (2013). Determination of oxalate: The total oxalate content was determined by the method of Mishra *et al.*, (2017). Determination of Tannins: The Tannins were determined using slightly modified AOAC (1980) method. Determination of Hydrogen cyanide: Hydrogen cyanide was determined using the alkaline titration method of AOAC (2006). Determination of phytates: Phytate was determined using a method reported by Yahaya *et al.*, (2013).

Statistical Analysis

Data from proximate and anti-nutrients' determinations were collected in triplicates and means $\pm$ standard deviations (SD) were computed. Data obtained were analyzed by one-way analysis of variance (ANOVA) using the SPSS version 17 (2014) statistical procedure and significance was accepted at $P < 0.05$ level of probability.

RESULT AND DISCUSSION

Table 1: (A) Mean Proximate Properties of “Mbuguru” and “Aniga” (DM)

Parameters	Ang	Mbu	WYF
% Protein	6.22 ^b	5.69 ^c	7.51 ^a
% Ash	5.10 ^a	3.90 ^b	3.93 ^b
% Fat	4.37 ^a	3.04 ^c	4.09 ^b
% C. Fibre	5.54 ^a	5.78 ^a	4.92 ^b
% Moisture	5.28 ^a	5.28 ^a	4.45 ^b
% Carbohydrate	73.52 ^c	76.33 ^a	75.11 ^b
Energy Kcal/g	357.99 ^a	364.71 ^a	367.26 ^a

(B): Mean Anti-nutrient Properties of the samples

Oxalate mg/100g	23.46 ^a	13.58 ^c	17.04 ^b
Saponins	0.16	0.21	0.40
Alkaloids	5.53 ^c	6.08 ^b	11.37 ^a
Phytate	281.06 ^c	360.16 ^b	406.82 ^a
Tannins	5.20 ^b	4.52 ^b	8.09 ^a
Cyanide	60.26 ^a	50.61 ^b	40.98 ^c

Values are means of triplicate determinations. Means with same superscript are not significantly ($P > 0.05$) different.

Key: Ang= Aniga flour, Mbu = Mbuguru flour, WYF = Water Yam Flour

Table 1A: reveals the proximate composition of the samples (expressed in percentages). There were significant ($P < 0.05$) differences in the values obtained in the parameters. The average crude protein content of the samples ranged between 5.69^c and 7.51^a. The “WYF” with no dilution, had the highest protein concentration with the 7.5% crude protein while dilutions from the water used for the cooking, might have encouraged leaching and

also, the heat of cooking and drying might have caused the loss of some amino acids. Wanasundera and Ravindaram (1994) reported water yam flour to have 7.4% crude protein content. One common change in the “Ang” and “Mbu” products is that “Ang” changes from the former whitish, to ashy colour after drying. Reactions with the cocoyam, heat of cooking and drying could be indicted for the colour changes. In the case of “Mbu” sample, the colour of the cooked product is dirty pink to light brown, and maillard reaction or infusion of the colour component of the dry/wilted plantain/banana leaves could readily be indicted. Through these reactions some of the crude protein components could be lost. **Fig 1**, shows the colours of the products, and maillard reaction in which some amino acids’ loss lead to brownish colours because of the effect of heat can be indicted for the shades of brown colours obtained in the freshly produced “Ang” and “Mbu. However, the protein content of “Ang” is higher than that of “Mbu” sample. Additionally, the protein of the added grated cocoyam mash might have contributed, unlike in “Mbu” sample which was only the grated water yam mash. Sometimes, the cocoyam leaves are included but for this report, no cocoyam leaf was added in the “Mbuguru” sample.

The contents of ash and fat were highest in “Ang” sample. For ash contents, the order was “Ang” (5.10%) > “WYF” (3.93%) > “Mbu” (3.90%) but there was no significant differences between “WYF” and “Mbu” ash contents. The fat content of “Ang” was 4.37%, followed by the 4.09% of “WYF” and 3.04% of Mbu.

The crude fibre content of the samples were in the order “Mbu” (5.78%) > “Ang” (5.54%) > “WYF” (4.92%) but there was no significant differences between the values of “Mbu” and Ang. The “WYF” sample thus had the least crude fibre content. Crude fibre encompasses both soluble and insoluble fibre. The positive health effect of fibres include that they delay food transit through the intestinal track. Viscous fibre systems delay glucose uptake in the blood, and help to lower blood cholesterol, while insoluble fibres prevent constipation, and are believed to decrease the incidence of colon cancer, (Murano (2003). The moisture range of the samples was between 4.45% and 5.28%. The flours with this range of moisture are expected to exercise some shelf stability as per the classification of shelf stability of products. The carbohydrate content of the samples ranged between 73.52% of “Ang” sample and 76.33% of the “Mbu” sample. Wanasundera and Ravindaram (1994) had credited water yam flour with 75.6% to 84.3% starch, and this study agrees with their report.

The calculated energy contents (Kcal/100g) of the samples ranged between 357.99 Kcal/100g and 367.26 Kcal/100g. However, there was no significant ($P > 0.05$) difference between the energy content of the sample. The energy values in this study compares with the energy values of 364.75 to 367.92 Kcal/100g reported by Ukom and Okerue (2018) for raw and processed *tannia* flours. High energy values of these products are of great importance to human health especially in alleviating protein energy malnutrition (PEM), particular as “Ang” and “Mbu” are yet to be enriched with palm oil-based gravy or local “ncha”, a palm oil in water emulsion.

The anti-nutrient compositions of the samples were presented in Table 1B and there are significant differences in the values obtained for the various parameters. Oxalate, Tannins, Phytates and Cyanides were measured in mg/100g while Saponins and Alkaloids were measured in percentages.

CONCLUSION

The study has shown that “Aniga” and “Mbuguru traditional foods have some proteins to offer as a means of solving food security and protein energy malnutrition (PEM). Enhanced production of such food products will promote Igbo traditional foods and emphasise less of exotic food products.

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STUDY OF DIFFERENT PROCESSING METHODS ON THE FUNCTIONAL & PROXIMATE COMPOSITION OF YELLOW GARI

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ABSTRACT

Rapid urbanization throughout sub-Saharan Africa is currently being accompanied by a growth in demand for convenience and staple foods such as *gari*. *Gari* is a dry, crispy, creamy-white/ yellow and granular roasted product made from cassava roots with a slightly fermented taste. It is a popular food in West Africa. *Gari* was produced using four different processing methods (yellow *gari*: YG and white *gari*: WG). It involved addition of palm oil before the fermentation process (YG1); at 48 h of fermentation (YG2); after 96 h of fermentation (YG3) and a control after 96 h of fermentation without the addition of palm oil (WG1). The result of the proximate analysis revealed that the protein content, the carbohydrate content, fat content and the crude fiber of the samples ranged between $1.27 \pm 0.06\%$ and $1.47 \pm 0.06\%$; $88.52 \pm 0.42\%$ and $91.19 \pm 0.92\%$; $0.87 \pm 1.33\%$ and $1.87 \pm 1.62\%$; $0.67 \pm 0.61\%$ and $0.93 \pm 0.81\%$ respectively. The pH ranged between 4.14 and 4.21, the bulk density; swelling index; and water absorption capacity ranged between 0.66 and 0.71; 1.62 and 2.00; 4.90 and 5.15 respectively. The processing method had an effect on the quality attributes of the *gari*.

Keywords: Cassava, Functional properties, Processing method, Proximate composition

INTRODUCTION

Cassava (*Manihot esculenta*) is a perennial woody shrub with an edible root, which grows in tropical and sub-tropical areas of the world. It is rich in carbohydrate, calcium, vitamin B and vitamin C as well as essential minerals. However, the nutrient composition differs according to variety and age of the harvested crop, soil condition, climate and other environmental factors during cultivation (Otekunrin and Sawicka 2019). It is also the most widely consumed staple food in Nigeria. The main traditional cassava products in Nigeria are *gari*, *fufu*, *tapioca* and *lafun* (Okechukwu and Okoye,

2010). *Gari* is a roasted product with a slightly fermented taste. It is made from yellow fleshed variety or from white roots fortified with red palm oil to make it yellow in colour; otherwise, it is creamy white. *Gari* processing in Nigeria is on the rise because it is seen as a convenience food; it is quick and easy to cook and can be stored. In both urban and rural market, *gari* competes with rice and cereals due to its low price and high convenience (DoA, 2013).

Materials and Methods

The freshly harvested cassava roots (*Manihot esculenta*) and palm oil used for this study were purchased from Arigbajom market Ifo, Ogun State, Nigeria. Yellow *gari* was made using three (3) processing methods. Cassava roots were properly cleaned and sorted to remove contaminants. The cleaned and sorted cassava roots were then peeled to remove the outer brown skin and washed to remove stain and dirt after which it was grated into a mash manually. The mash was divided into four (4) portions. The four portions of the mash were packed in different jute bags and tied and a heavy load was placed on the bag to remove excess water and to initiate the process of fermentation for 4 days (96 hours) at room temperature, known quantity of palm oil was added to the first portion of the mash prior to fermentation (YG1), second portion of the mash after 48 h of fermentation (YG2), third portion of the mash after 96 h of fermentation (YG3) and the fourth portion was fermented for 96 h without the addition of oil after fermentation. Each portion of the mash was sieved and toasted separately in a shallow pan for 30 minutes under controlled temperature. (modified method of Okolie *et al.*, 2012).

The proximate analysis and pH of the products was carried out using AOAC, (2005). Total carbohydrate content was determined by deferential. Water absorption capacity and bulk density was determined according to the method described by Onwuka (2005), swelling index and the reconstitution index of the samples was determined using the method of (Olaitan *et al.*, 2014). Data were analyzed by the one-way Analysis of Variance (ANOVA) model using the IBM SPSS 20.0

RESULTS AND DISCUSSION

Proximate Composition and the pH of the Gari

Table 1 showed the results obtained for the proximate composition and the pH of the *gari* produced. The values of moisture content ranged between 5.07% and 7.73% with YG3 having the highest value and YG1 having the least value. All the *gari* samples generally had low moisture content which was within the range reported by Abue *et al.* (2006) which indicated that the maximum moisture content of *gari* should be 12%. Good

quality *gari* should have low moisture content which enhances its storability. The values for protein ranged between 1.27 and 1.47%. Sample YG3 had the highest value while sample WG1 and YG2 had the same value of 1.27. The result of the protein content of *gari* was in correlation with the report of Komolafe and Arawande (2010). The values of fat content ranged from 0.87%-1.87% with YG2. The control WG1 had the least value for fat content. This may be due to the addition of palmoil in the yellow *gari* while WG1 did

not have any palmoil. Also the general low fat content may be as a result of the cassava root being composed mainly of carbohydrates and

therefore a starchy food. The ash content of all samples had the same values which was 0.01%. The addition of palm oil did not have any significant effect on the ash content of all the *gari* samples. The maximum value for crude fiber was 0.93% for YG1 while the minimum value was 0.67% for sample YG3. There was no significant difference between the samples as regards carbohydrate content. The results ranged between 88.59% and 91.19. The cassava root is composed mainly of carbohydrates and therefore mainly supplies energy. The pH values ranged between 4.14 and 4.21. This showed the acidic nature of the *gari* which may be due to the fermentation period.

A longer fermentation period has been reported to be associated with higher production of lactic acid, which gives the *gari* the strongly desired acidic flavour

Functional Properties of Gari Produced from Different Processing Methods

The functional properties of the *gari* is presented in table 2. The bulk density varied between 0.64g/cm³ and 0.71g/cm³. The results were within the acceptable range of 0.55g/cm³ to 0.82g/cm³ reported by Komolafe and Arawande (2010). The bulk density determines packing and handling method of a sample and is very important in transport considerations. Bulk density can be influenced by the structure of starch polymers and loose structure of starch polymers could result in low bulk density. Thus, the lower the bulk density, the higher the floatation of *gari* samples in water which could result in the *gari* not soaking properly in water and may in turn be rejected by consumers. The water absorption capacity (WAC) ranged between 4.90g/ml and 5.15g/ml. Sanniet. al. (2005) reported that the swelling index of granules reflects the extent of associative forces within the granule, therefore the higher the swelling index, the lower the associative forces. The maximum value for swelling index was 2.12g/ml while the least value was 1.62g/ml. High swelling capacity gives greater volume and more feeling of satiety and it also indicates degree of gelatinization of *gari*. A good quality *gari* should swell to at least three times its volume when soaked in water. The constitution index ranged from 6.20 to 8.10g/ml which was the maximum value and was for the control sample while YG3 had the lowest value of 6.20g/ml.

Table 1: Proximate composition and pH value of *gari* produced using different methods

Sample	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	pH
WG1	6.13 ^b ±5.33	0.87 ^d ±1.33	1.27 ^c ±0.15	0.01 ^a ±0.02	0.87 ^{ab} ±0.81	90.85 ^a ±49.92	4.20 ^a ±0.13
YG1	5.07 ^c ±4.39	1.47 ^{ac} ±1.29	1.33 ^b ±0.12	0.01 ^a ±0.02	0.93 ^a ±0.81	91.19 ^a ±50.32	4.14 ^{ab} ±0.13
YG2	7.53 ^{ab} ±6.56	1.87 ^a ±1.62	1.27 ^c ±0.06	0.01 ^a ±0.02	0.80 ^{ac} ±0.72	88.52 ^{ab} ±48.42	4.21 ^a ±0.11
YG3	7.73 ^a ±6.70	1.53 ^{ab} ±1.33	1.47 ^{ab} ±0.06	0.01 ^a ±0.01	0.67 ^b ±0.61	88.59 ^{ab} ±48.08	4.19 ^a ±0.04

Values are expressed means of triplicate values ±SD

Table 2: Functional Properties of the produced using three different methods

Sample	Bulk density	WA C	Swelling index	Reconstitution index
WG1	0.66 ^{ab} ±0.01	4.90 ^b ±0.00	2.00 ^a ±2.83	8.10 ^a ±0.14
YG1	0.64 ^{ab} ±0.00	5.05 ^{ab} ±0.07	1.87 ^{ab} ±2.65	7.70 ^{ab} ±0.14
YG2	0.64 ^{ab} ±0.00	5.15 ^a ±0.07	1.62 ^b ±2.29	6.80 ^b ±0.84

Data are expressed as Mean of triplicate values ±SD. WAC-Water absorption capacity

Conclusion

The results obtained in proximate analysis showed that the *gari* was of good quality and that the quality of the *gari* can be affected by processing methods

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DRIVERS OF THE CONSUMER ACCEPTABILITY OF SWEET POTATO POUNDO PRODUCED FROM DIFFERENT STEAMING TEMPERATURES AND TIMES

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Abstract

This study aimed to evaluate the drivers of the consumer acceptability of sweet potato pouno (SPP). The SPP was produced using different steaming temperatures and times (80°C:5mins, 84°C:9mins, 90°C:7.5 mins, and 104°C:7.5 mins), and then analyzed for biophysical and textural attributes and consumer acceptability in three locations (Safari, Malete, and Asomu) of Kwara State. The principal component analysis shows that the 90 °C: 7.50 min SPP was in the same quadrant with the water absorption capacity, zinc content, sensory hardness and mouldability, instrumental hardness and gumminess, and the consumer acceptability of the dough in all the locations. Also, the consumer acceptability of the SPP was negatively correlated ($p < 0.05$) with the carbohydrate ($r = -0.88$) and amylose ($r = -0.94$) contents, and the sensory stickiness ($r = -0.95$) of the cooked dough, while a positive correlation was observed with the water absorption capacity of the SPP ($r = 0.97$), and the sensory hardness ($r = 1.00$) and mouldability ($r = 0.76$), as well as the instrumental hardness ($r = 0.89$) and gumminess ($r = 0.84$) of the cooked dough. Thus, the drivers of the consumer acceptability of the 90 °C: 7.50 min SPP may be the sensory hardness and mouldability, and the instrumental hardness and gumminess, which might have been influenced by the positive contribution of the water absorption capacity of the SPP.

Keywords: Sweet potato pouno, Cooked dough, Biophysical, Textural attributes, Consumer acceptability

Introduction

Sweet potato has become a research focus due to its versatility and adaptability to variation in climatic conditions. Its versatility ranges from cooking, roasting, sparring production, confectionaries, flour, crisps, animal feed, starch, sweet potato beer, and sweet potato beverages to pounding (Egeonu, 2004). However, pounding sweet potatoes using mortar and pestle just like yam is strenuous and time-consuming in areas where it is consumed as staples, hence, the production of sweet potato pouno. The sweet potato pouno (SPP) being a new product, therefore needs textural profiling of the cooked dough, which may assist in the evaluation of the consumer acceptability of the product in addition to the biophysical attributes. Therefore, this study is aimed at evaluating the drivers of the consumer acceptability of sweet potato pouno produced at different steaming temperatures and times.

Materials and Methods

The sweet potato tubers were bought from a local market in Ilorin and processed into SPP using the worst (104°C: 7.50 min), medium (80°C: 5 min), and best (90°C: 7.50 min) steaming temperatures and time obtained from the sensory analysis, as well as the optimum temperature (84°C) and time (9 min) obtained from the optimization result reported by Salimon (2020). The functional, pasting and chemical composition of the SPP were analyzed using standard methods. The SPP (250 g) was cooked in boiling water (100 ml) by stirring to make a glutinous cooked dough (Salimon, 2020). The well-coded cooked dough samples were kept in a warmer before the sensory and instrumental texture profiling. The instrumental texture profiling was done using a texture analyzer interfaced with an IBM computer, and the sensory texture profiling was done using a well-structured questionnaire with 15 trained panelists (Awoyale et al., 2021). The consumer acceptability of the dough was carried out in three locations (Safari, Malete, and Asomu) using a well-structured questionnaire with 50 respondents in each location (Awoyale et al., 2021). The principal component analysis (PCA) of the data was done using XLSTAT free version.

Results and Discussion

Table 1 shows the correlation loading of the biophysical traits of the SPP and the textural attributes and consumer acceptability of the cooked dough. The result depicts that the principal component 1 (PC1) was positively correlated with the SPP bulk density ($r=0.94$), water absorption capacity ($r=0.97$), least gelation concentration ($r=0.91$), peak viscosity ($r=0.96$), setback viscosity ($r=0.91$), pasting temperature ($r=0.96$), zinc ($r=1.00$), iron ($r=0.93$), the cooked dough sensory stretchability ($r=0.96$), hardness ($r=1.00$) and mouldability (0.76), and the instrumental hardness ($r=0.89$) and gumminess ($r=0.84$), but negatively correlated with the SPP swelling power ($r=-0.76$), carbohydrate content ($r=-0.88$), amylose content ($r=-0.94$), and the cooked dough sensory stickiness ($r=-0.95$) and instrumental mouldability ($r=-0.64$). The consumer acceptability of the cooked dough was also positively correlated with principal component 1 (PC1) in all the locations ($r=0.95$). The PCA biplot, as shown in Figure 1, allowed us to separate the SPP samples based on the biophysical and textural attributes and the consumer acceptability of the cooked dough. The result showed a data variance of about 95.43%, with PC1 contributing 79.73% and PC2 15.70%. The 104 °C: 7.50 min SPP was in the same quadrant with the least gelation concentration, bulk density, peak viscosity, setback viscosity, pasting temperature, iron content and the sensory stretchability of the cooked dough. Similarly, the 90 °C: 7.50 min SPP was in the same quadrant with the water absorption capacity, zinc content, the cooked dough sensory hardness and mouldability, the instrumental hardness and gumminess, and the consumer acceptability in Safari, Malete and Asomu. The 84 °C: 9 min SPP was in the same quadrant with the swelling power and the cooked dough instrumental mouldability. Also, the 80 °C: 5 min SPP was in the same quadrant as the carbohydrate and amylose contents, and the cooked dough sensory stickiness and instrumental adhesiveness (Figure 1). Figure 1 also shows that the consumer acceptability of the cooked dough was negatively correlated ($p<0.05$) with the carbohydrate ($r=-0.88$) and amylose ($r=-0.94$) contents of the SPP, and the sensory stickiness ($r=-0.95$) of the cooked dough, but a positive correlation with the water absorption capacity of the SPP ($r=0.97$), and the sensory hardness ($r=1.00$) and mouldability ($r=0.76$), and the instrumental hardness ($r=0.89$) and gumminess ($r=0.84$)

of the cooked dough. Therefore, the consumer preference for the poundo produced from the steaming temperature of 90 °C and steaming times of 7.50 min for all the locations may be attributed to the sensory hardness and mouldability, and the instrumental hardness and gumminess, which might have been influenced by the positive contribution of the water absorption capacity of the poundo.

Conclusion

Since, the consumer acceptability of the SPP was negatively correlated with the carbohydrate and amylose contents, the sensory stickiness of the cooked dough, and positively correlated with the water absorption capacity of the SPP, the sensory hardness and mouldability, and the instrumental hardness and gumminess of the cooked dough. Therefore, the drivers of the consumer acceptability of the 90 °C: 7.50 min SPP may be the sensory hardness and mouldability, and the instrumental hardness and gumminess, which might have been influenced by the positive contribution of the water absorption capacity of the SPP.

Acknowledgment

The instrumental texture attributes of the cooked dough were carried out at the Food and Nutrition sciences laboratory of IITA, Ibadan, Nigeria. Appreciation to the consumer testing panelist at Safari, Malete and Asomu communities.

Table 1. Correlation loading of the biophysical traits of the instant sweet potato flour, and the textural attributes and consumer acceptability of the cooked dough

Attributes	F1	F2	F3
Bulk density	0.94	0.33	-0.11
Water absorption capacity	0.97	-0.23	0.00
Swelling power	-0.76	-0.65	0.06
Least gelation concentration	0.91	0.37	-0.16
Peak viscosity	0.97	0.22	-0.11
Setback viscosity	0.91	0.34	-0.22
Pasting temperature	0.96	0.24	-0.12
Carbohydrate content	-0.88	0.33	0.34
Amylose content	-0.94	0.20	0.29
Zinc content	1.00	-0.02	0.04
Iron content	0.93	0.31	-0.22
Sensory stretchability	0.96	0.14	0.23
Sensory hardness	1.00	-0.08	0.02
Sensory stickiness	-0.95	0.09	-0.31
Sensory mouldability	0.76	-0.64	0.05
Instrumental hardness	0.89	-0.35	0.29
Instrumental adhesiveness	-0.11	0.87	0.47
Instrumental mouldability	-0.64	-0.76	-0.12
Instrumental gumminess	0.84	-0.46	0.30
Safari consumer acceptability	0.98	-0.19	0.04
Asomu consumer acceptability	0.94	-0.20	0.27
Malete consumer acceptability	0.96	-0.27	0.07

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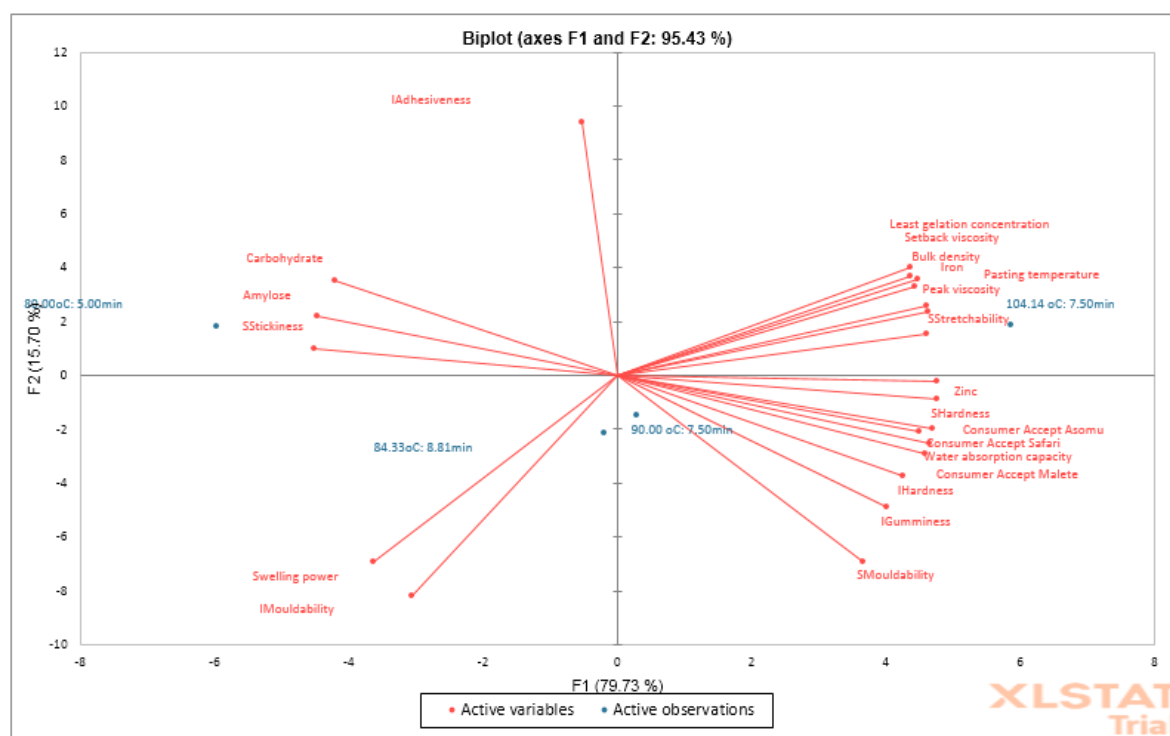


Figure 1. Principal component biplot of the biophysical traits of the instant sweet potato flour, and the textural attributes and consumer acceptability of the cooked dough produced from different steaming temperatures and times.

SSStretchability-Sensory stretchability, SHardness-Sensory hardness, SStickiness-Sensory stickiness, SMouldability-Sensory mouldability, IHradness-Instrumental hardness, IAdhasiveness-Instrumental adhesiveness, IMouldability-Instrumental mouldability, IGumminess-Instrumental gumminess

PROXIMATE COMPOSITION AND GLYCEMIC INDEX OF FUFU FROM SWEET POTATO AND COCOYAM FLOUR BLENDS.

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Abstract

This work discusses the proximate composition and glycemic index of *fufu* made from sweet potato and cocoyam flour blends. The Sweet potato and Cocoyam flour was blended in the ratio of 50SPF: 50CF, 70SPF: 30CF, 80SPF: 20CF and 100% SPF. The glycemic index of the *fufu* were measured by feeding four out of the five groups of wistar rat with the formulated samples respectively and the fifth group fed

with 100 % pure glucose as reference feed. The glycemic index value ranged from 30 to 63 and was observed to decrease as the level of sweet potato flour was increased. The result showed that the moisture content (7.5 -9.8 %) of the flours were within the storable level and decreased with increase in cocoyam level. The protein, ash and fat content of the flours increased with increase in cocoyam level. The fibre decreased with increase in cocoyam flour. The result revealed that blending improved the proximate composition of the flour and decreased the glycemic index.

Keywords: Proximate composition, Glycemic index, Fufu, Sweet potato, Cocoyam

Introduction

Fufu is soft dough made from various starchy roots, tubers and cereals which is eaten with soup as one of the major meals in Africa especially in Nigeria where it is widely consumed. These crops (cassava, sweet potato, cocoyam, yam) are known to be deficient in protein which of great concern in some parts of the world especially in African. Cocoyam is among the most important tuber crops in the tropics (Nwanekezi *et al.*, 2010). In Nigeria, it is majorly grown in Eastern and Western Nigeria where it is also processed into *fufu*. Cocoyam is considered to be nutritionally superior in terms of protein, vitamins and minerals when compared to other tubers (Duru and Uma, 2002). Its cultivation is still very poor due to lack of information on its utilization (Agbemolope, 2013). Cocoyam consumption is usually limited to areas where they are produced due to high cost of transportation and the risk of spoilage of the corms and cormels. The *colocasia* species is used as thickeners in preparation of bitter leaf soup after boiling and pounding, a delicacy in parts of Eastern Nigeria. It can be converted into chips called *achicha*.

Sweet potatoes belong to the family *Convolvulaceae*. Sweet potato is ranked fifth in the tropics as an important tuber crop and seventh in the world (Ray and Ravi, 2005; Tortoe, 2010). It is high in carbohydrate, moisture, β -carotene, vitamin C, B-vitamins,

calcium, iron, manganese, copper, potassium and phosphorus but low in protein and fat (Burri, 2011). Although the proximate composition of the different crops has been investigated elsewhere, same has not been conducted in the combination of its flour. Proximate composition is an important part of food processing and marketing. It provides basic information on the chemical properties of food which is usually displayed on packaging material.

Sweet potato is produced in commercial quantity in Ebonyi State and its uses are limited to boiling, frying and roasting. There is need to find alternative use of sweet potato in other to expand its utilization. Preliminary studies showed that *fufu* made from sweet potato does not bind well. It disintegrates easily. Its continuous use as *fufu* requires a binder. The potential of cocoyam as filler and binders in food industry have been identified (Ijeoma, 1985). This informed the decision to incorporate cocoyam into sweet potato. The objective of the study is to determine the proximate composition and glycemic index of *fufu* made from sweet potato and cocoyam flour blends.

Material and Methods

Sample collection

Fresh white sweet potato and cocoyam corm was purchase from Eke Oshiri market in Onicha local government area, Ebonyi state.

Sample preparation

Sweet potatoes (SPF) was washed, peeled and chopped into 2mm thickness. The slices were soaked in tap water for 24 hours. After soaking the slices were sundried, milled into flour while cocoyam (CYF) corm was washed, peeled, sliced , boiled for 20 minutes, sun dried, milled into flour and stored in air tight plastic containers at room temperature (28 °C; 24% R.H.) for further analysis. The two flours were combined in the ratio of 80SPF:20CYF, 70SPF:30CYF, 50SPF: 50CYF and 100CYF. The proximate composition of the samples were determined using standard methods.

The glycemic index (GI) for each diet was calculated as the ratio of incremental area under two hours of blood glucose response or Curve (IAUC) for each diet to the IAUC for glucose solution standard according to the method of (Wolever *et al.*, 1991).

Results and Discussions

The result of the proximate composite of *fufu* made from sweet potato and cocoyam flour is as shown in Table 1. The moisture content of 100 % SPF was the highest while SPF80:CY20 had the least value. The moisture content decreased with inclusion of cocoyam flour. However, all the samples had low moisture content (M C < 10%) which mean the product will store for long. Protein, ash and fat contents increased significantly ($P < 0.05$) with increase in cocoyam flour. Increase in ash content could be attributed to incorporation of cocoyam flour. Increase in ash suggests the product to be a good source of minerals. Increase in protein, ash and fat contents could be attributed to inclusion of cocoyam flour to the *fufu* as cocoyam has been reported to be high in protein, fat and ash

among roots and tuber. From the results, it was observed that inclusion of cocoyam produced fufu that has enhanced proximate composition of the developed meal.

The result of the glycemic index of *fufu* produced from sweet potatoes and cocoyam flour is presented in Figure 1. From the result 100% sweet potatoes flour had a value of 63 which could be considered an intermediate GI food. The results also revealed that addition of cocoyam flour to sweet potatoes significantly ($P < 0.05$) decreased the GI value of the resultant blends. The low GI diet is good as it has been reported to decrease the incidence of diabetes, carbohydrate absorption in the small intestine, postprandial glucose rise; daily insulin levels, 24 hours urinary peptide output; suppression of plasma free fatty acids among others (Pasupuleti and Anderson, 2008).

Conclusion

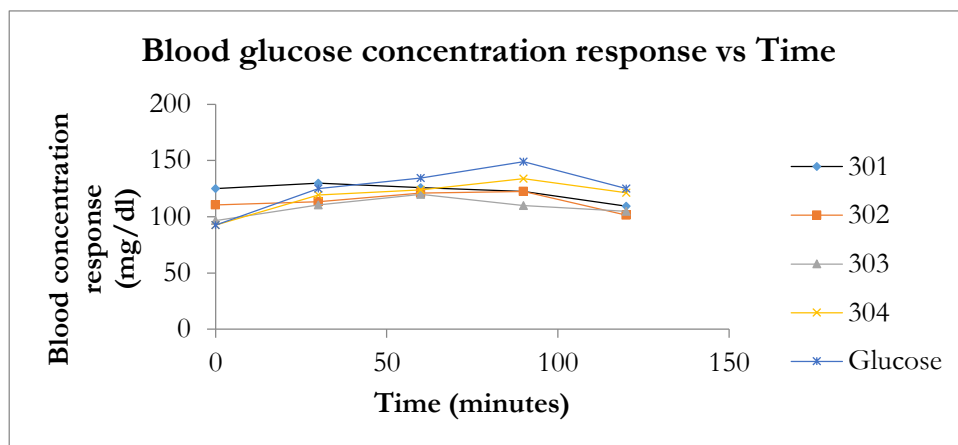
From the study, *fufu* made from the blends gave better proximate properties. Addition of cocoyam to sweet potato increased the protein, ash and energy content of the diet. The result showed that *fufu* made from Sweet potato and Cocoyam flour blends had low glycemic index except for 50 SPF: 50CF which had medium glycemic index which makes it good for obese and diabetic individuals.

Table 1: Proximate Composition of fufu flour made from Sweet Potatoes and Cocoyam Flour.

Parameters	SPF80CY20	SPF70CY30	SPF50CY50	SPF100%
(%)				
Moisture	7.5 ^b ±1.00	8.0 ^{ab} ±1.00	8.3 ^{ab} ±1.25	9.8 ^a ±0.75
Ash	4.25 ^b ±0.75	4.9 ^b ±0.95	7.8 ^a ±0.28	3.0 ^c ±0.65
Protein	3.3 ^c ±0.30	5.5 ^b ±0.30	8.7 ^a ±0.93	2.7 ^c ±0.10
Fibre	5.0 ^a ±0.10	4.5 ^b ±0.48	3.5 ^c ±0.11	5.1 ^a ±0.09
Fat	0.8 ^{bc} ±0.15	1.5 ^{ab} ±0.50	1.9 ^a ±0.50	0.7 ^c ±0.10
Carbohydrate	79.1 ^a ±1.60	75.7 ^b ±0.94	69.8 ^c ±1.42	78.8 ^a ±0.79
Energy(KJ/100g)	1420 ^a ±27.27	1411.4 ^a ±16.11	1385 ^a ±26.87	1390.5 ^a ±11.15

Values are means ± standard deviation of triplicate analysis. Means with the same superscripts in the same row are not significantly different at ($p < 0.05$)

Where: SPF= White fleshed sweet potatoes flour, CYF= Cocoyam flour



301 = SPF50:CY50

302 = SPF70:CY30

303 = SPF80:CY20

304 = SPF100%

Figure 1 : Glycemic index of fufu from sweet potato and cocoyam flour

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GLYCEMIC INDEX AND PROXIMATE COMPOSITION OF FUFU MADE FROM COCOYAM AND UNRIPE PLANTAIN FLOUR BLENDS.

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Abstract

The glycemic index and proximate composition of *fufu* made from Cocoyam and Unripe plantain flour was investigated. The cocoyam and unripe plantain was peeled, washed chipped, into 3mm thickness and blanched in hot water for 10 minutes, sundried and milled. Each of the flour was divided into four portions of 60 CYF: 40 PTF, 50CYF: 50 PTF, 70 CYF: 30PTF and 100 % CYF. The glycemic index ranged from 17.3 to 46. 2 with 60CYF: 40PTF having the highest value, while 100 % CYF had the least value. The result also revealed that blending slightly increased the proximate composition but was not significantly ($P < 0.05$). It was observed that diet made cocoyam flour can be administrated on diabetic patient since the result shows that it is a low glycemic index food.

Keyword: Glycemic index, Proximate composition, Cocoyam, Unripe plantain, Fufu

Introduction

Fufu is among the staple diet popularly eaten by people especially adults in Nigeria. *Fufu* is produced majorly from cassava, yam and cocoyam which contribute to energy and nutritional need of billions of people in the developing nations (Obadina *et al.*, 2006). It can also produce from cereals such as maize, wheat, plantain which in most cases are transformed into flour. Transformation of this indigenous roots and tuber into flour has become necessary as *fufu* in their wet form has poor shelf life and less convenient. Plantains belong to the family *Musaceae* Plantain is ranked third important starchy food crop in the tropics (FAO, 2006) Plantains can be consumed either ripe or unripe in various forms such as boiled, fried, roasted, pounded into *fufu* eaten with any Nigerian soup. Unripe plantain is traditionally processed into flour in Nigeria (Ukhum and Ukpebor, 1991). This flour is usually mixed with boiled water to make 'eba' which is eaten with various sauces. The flour is also used in making various traditional meals such as 'akara', ukpo ogede and soups ((Onuoha, *et al.*, 2014). Plantain are rich in carbohydrate, vitamin, minerals but in fat. Cocoyam is high in carbohydrate and is eaten either by boiling or transformed into chips which are prepared into porridge and eaten with different legumes. Sweet potatoes and cocoyam is a major starchy staple for many household in African especially Nigeria. Most starchy crops when processed into *fufu* undergo retrogradation. This phenomenon results to loss of elasticity of the paste and is mostly undesirable by consumer. Incorporation of cocoyam flour into plantain flour will likely prevent this retrogradation. The level of utilization of this developed *fufu* is independent on physicochemical properties and its glycemic index. Unripe plantain is usually recommended to Nigerian diabetics to reduce post-prandial blood glucose level (Foster *et al.*, 2003). This is because unripe plantain is a low glycemic index food because plantain contains slowly digestible starch which sugars

are released slowly over time (Onuoha, *et al.*, 2014). Unripe plantain is expensive despite its low glycermic index which makes it unaffordable for low income earners. Therefore there is need to develop a diet from plantain which will be affordable by low income diabetic patients, these informed the incorporation of cocoyam into plantain. There are report on the glycemic index of unripe plantain flour, but there are no information on the proximate composition and glycemic index of *fufu* produced from the combination of unripe plantain and cocoyam flour.

Material and Methods

Sample collection

Fresh unripe plantain and cocoyam corm was purchase from Kpiri-Kpiri Market Abakaliki, Ebonyi state.

Sample preparation

Unripe plantain (PTF) was washed, peeled, and chopped into 2mm thickness. The slices were blanched with hot water at 80⁰ C for 10 minutes. After blanching, the slices was sundried, milled into flour while cocoyam (CYF) corm was washed, peeled, sliced corm was washed, peeled, sliced into sliced, boiled for 20 minutes, sun dried, milled into flour and stored in air tight plastic containers at room temperature (28 °C; 24% R.H.) for further analysis.

Formulation of sample

The flour was combined in the ratio of 60PTF:30CYF, 70PTF:30CYF, 50PTF: 50CYF and 100CYF.

Analysis of sample

The proximate composition of the samples was determined using standard methods.

The glycemic Index (GI) for each diet was calculated as the ratio of Incremental Area Under two hours of blood glucose response or Curve (IAUC) for each diet to the IAUC for glucose solution standard according to the method of (Wolver *et al.*, 1991).

Result and Discussion

The result of the proximate composite of *fufu* made from plantain and cocoyam flour is as shown in Table 1. The moisture content of 70 % CYF: 30%PTF was the highest while 60%CYF: 40%PTF had the least value. The moisture content increased with inclusion of plantain flour. However, all the samples had low moisture content (M C < 10%) which mean the product will store for long. There was no significant change in the Protein, ash and fat contents with increase in plantain flour. This was expected as plantain has been reported to be in fat and protein. The high ash content in this study suggests that the product is a good source of minerals. From the results, it was observed that inclusion of plantain produced *fufu* that was cohesive and did not enhanced the proximate composition of the developed meal.

The result of the glycemic index of *fufu* produced from cocoyam plantain flour is presented in Figure 1. From the result 100% cocoyam flour had a value of 17.3 which could be considered low GI food. The results also revealed that addition of plantain to cocoyam flour increased the GI value of the resultant blends. The low GI diet is good as it has been reported to decrease the incidence of diabetes, carbohydrate absorption in the small intestine, postprandial glucose rise; daily insulin levels, 24 hour urinary c-peptide output; suppression of plasma free fatty acids among other.

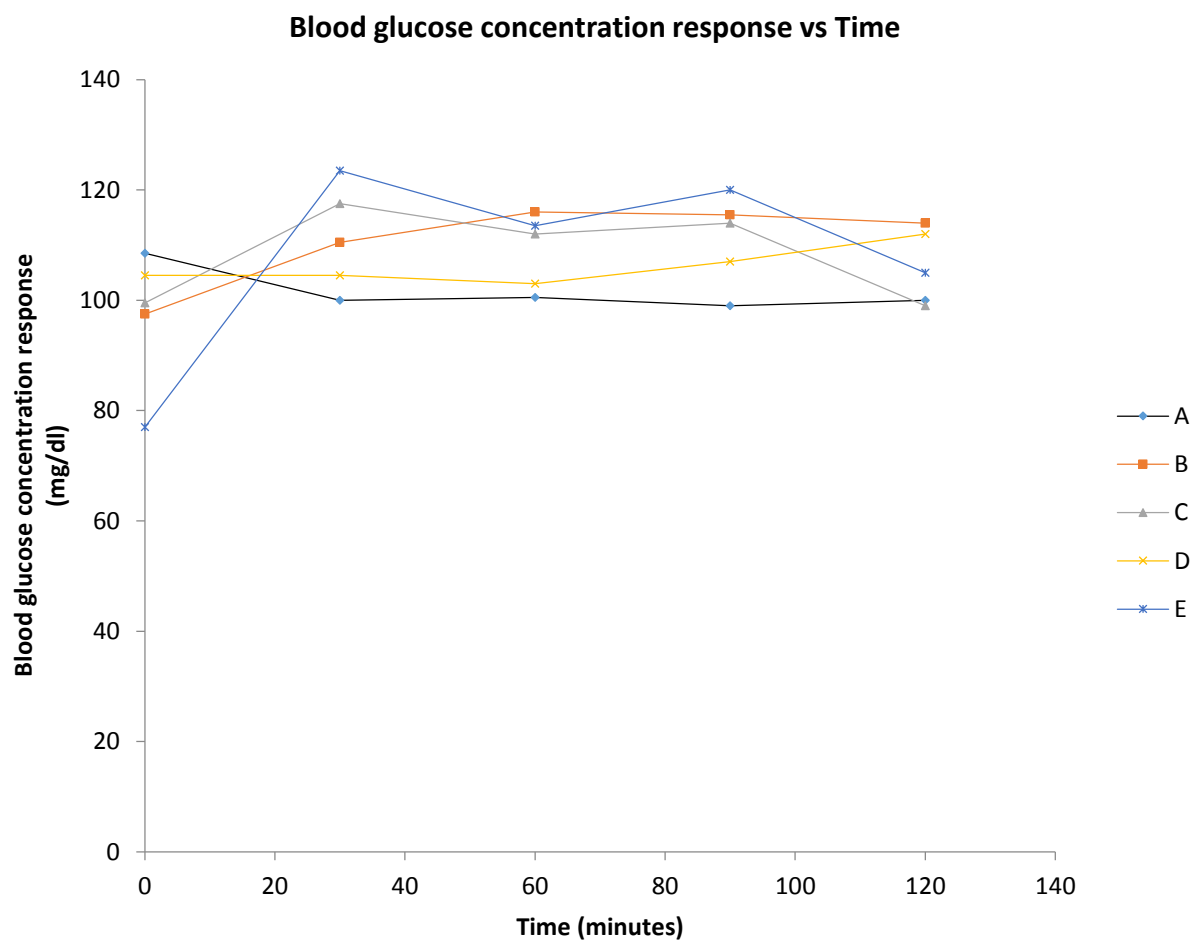
Conclusion

From this study the following conclusion can be drawn. The moisture content was within the storable moisture content for powdered food material. The ash and fibre increased with incorporation of unripe plantain flour. The 100 % cocoyam flour had the lowest glycemic index.

Table1: Proximate composition of composite flour from cocoyam flour and plantain flour

Parameter	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Carbohydrates (%)
70%CYF:30%PTF	8.15 ^a ±0.071	4.75 ^a ±0.35	1.50 ^a ±0.71	17.0 ^a ±0.28	0.62 ^a ±0.04	68.04 ^a ±0.89
50%CYF:50%PTF	8.10 ^a ±0.99	4.25 ^a ±0.35	1.6 ^a ±0.00	16.8 ^a ±0.28	0.61 ^a ±0.02	68.80 ^a ±1.69
60%CYF:40%PTF	7.80 ^a ±0.00	4.75 ^a ±0.35	1.8 ^a ±0.00	16.1 ^a ±0.71	0.53 ^a ±0.04	70.02 ^a ±0.11
100%CYF	7.80 ^a ±0.00	3.75 ^a ±1.77	2.8 ^a ±1.41	16.6 ^a ±0.28	0.55 ^a ±0.02	67.51 ^a ±0.49

Values are mean ± SD. mean with different superscripts along the same row are statistically different (P<0.05).70%CYF:30 %PTF, 50%CYF:50%PTF, 60%CYF:40%PTF, 100%CYF



A = 100 % cocoa yam flour, B = 50%CYF:50%PTF, C = 70 % CYF : 30 % PTF, D =60%CYF:40%PTF

E = 100 % PTF

Fig 1: Glycemic response of cocoyam and unripe plantain flour blends

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EFFECT OF STAGES OF INCLUSION OF COWPEA HULL ON IN-VITRO STARCH AND PROTEIN DIGESTIBILITY OF *GARI*

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Abstract

Cassava was enriched with cowpea hull to make enriched *gari* so as to increase the nutritional value of *gari* and prevent qualitative and quantitative post-harvest loss of the hulls which are thrown away during the production of some traditional food such as *moi-moi*. This study was aimed to determine the effect of stages of inclusion of cowpea hull on in-vitro starch and protein digestibility of *gari*. Factorial design of 2 stages of inclusion (before and after fermentation) and 3 levels of cowpea hull {(2X3) +1} six treatments and standard methods were used to produce and analyzed the *gari*. Addition of cowpea hull and fermentation significantly affects the protein and starch digestibility of the *gari*. Enrichment of *gari* using this food material is therefore recommended.

1.0 INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a widely cultivated root crop regarded as the second most consumed crop after maize which is capable of growing on marginal soils due to its drought-tolerant nature. It contributes to food security, renders an important source of dietary carbohydrate and a major staple food that matches the population growth in Africa and many other parts of the tropics, including Nigeria. Consumable products from cassava are numerous which include *fufu*, *lafun*, tapioca, *gari* and many other West African traditional dishes. *Gari* is a granular products obtained by fermentation, partially gelatinized and roasted. It is the most popular cassava food in many countries of West Africa and its consumption has continued to widen cutting across all social strata and age groups (Karim *et al.*, 2015). However, it is low in protein, deficient in essential amino acids and therefore, has poor qualitative and quantitative protein content. The enrichment of *gari* has been carried out using different plant materials such as cowpea and report has shown the adequacy of this crop in improvement of phytochemicals, starch and protein digestibility but none has enriched *gari* with cowpea hulls which are discarded after de-hulling during the production of traditional foods such as steamed bean cake (*moi-moi*), fried bean cake (*akara*) and beans soup (*gbegiri*). Literature abounds on the nutritional qualities of cowpea hull (Adebisi *et al.*, 2010). This research therefore focused on the enrichment of *gari* with cowpea hulls, determination of best inclusion level for improved protein and starch digestibility.

2.0 MATERIALS AND METHODS

2.1 Materials

Freshly harvested cassava root variety (TME 419) was harvested from Root and Tuber Expansion Programme (RTEP) farm in Ajase Ipo, Kwara State. The cassava roots were at the point of harvest within their optimum harvest maturity. The harvested roots were

packed in jute bags and immediately transported to a *gari* production factory in the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin for processing into *gari*.

2.2 Methods

2.2.1 Production of Cowpea hull, *gari* and factorial design of the study

Modified method of Adebisi *et al.*, (2010) was used for the production of cowpea hull. Fresh cowpea seeds which were free from insect infestation or chemical residues were used in this study to obtain cowpea seed hull. The cowpea seed hull was extracted using a manual method. The seeds were cleaned to remove stone, debris, unwanted particles, sands etc. and then soaked in clean water for 5-10 minutes for easy separation of the hull from the seed. After de-hulling, the hulls were then cleaned again to remove residual dirt or husk then roasted in a dry pot and finally cooled to make it ready for use and prevent mould formation during storage and the method described by Karim *et al.* (2015) was used to produce *gari*. Freshly harvested cassava roots obtained from Root and Tuber Expansion Programme (RTEP) farm in Ajase-Ipo, Kwara State were peeled manually with the use of sharp stainless knife. This was done as thorough as possible to ensure no fragment of red peel remained. Peeled roots were washed thoroughly in potable water to remove soils, dirt and other extraneous materials that might be present from peeling operation. Thereafter, the peeled cassava roots were grated into a smooth mash with the aid of a diesel-powered locally fabricated motorized grater. The grated cassava mashes were packed into porous jute bags, tied and left to ferment for 5 days for control samples. After fermentation, the cassava mashes, while still in the jute bags, were pressed in a hydraulic press for few hours. Then for the other mash in a separate jute bags, prepared and weighed cowpea hulls were added before and after fermentation. This is expected to have reduced the moisture content of the mashes to 40-50% (Abass *et al.*, 2013). The resulting wet cassava cakes obtained following dewatering were broken with hands and sieved through a hand-woven sieve to remove fibrous materials and lumps. These were then roasted in an earthenware over wood fire until dry enough as signaled by creamy colour and crispy hand-feel (Oti *et al.*, 2010). The *gari* samples obtained were allowed to adequately cool at room temperature for about 6 h before being packaged in polyethylene packs for subsequent analyses while factorial design of 2 stages of inclusion (before and after fermentation) and 3 levels of cowpea hull ((2X3) +1) six treatments was used for the study.

2.2.2 *In-vitro* starch digestibility

In vitro starch digestibility of the enriched *gari* was determined using the method described by Englyst *et al.*, (2008) with slight modification. The enriched *gari* was incubated with pepsin for proteolysis. About 1.5 g of the sample was transferred to 50 mL centrifuge tubes. Then, 5 mL of 50% saturated benzoic acid solution and 10 mL of pepsin guar-gum solution (5 g each per litre of 0.05 M HCl) was added. Guar gum was added to standardise the viscosity of the solution. To initiate proteolysis, each tube was covered, vortex-mixed, and transferred to a water bath for 30 min at 37 °C. To each tube, 5 mL sodium acetate buffer solution (0.5 M) at pH 5.2 and 15 glass beads of 5 mm diameter were added, shaken gently and equilibrated for 3 min in the water bath. Then, fresh enzyme cocktail was made from amyloglucosidase (260 U/mL), invertase (300 U/mg) and pancreatin (8 × USP) at ratio 4:6:18 per 100 mL enzyme mixture. Five millilitres of enzyme cocktail was added to each tube and agitated at 137 rpm in a shaking water bath set at 37 °C. Each tube was timed and

removed from the water bath at exactly 20 and 120 min after the addition of the enzyme. Approximately 0.2 mL of the digest was pipetted into 4 mL absolute ethanol and vortex-mixed to end enzymatic hydrolysis. These were G20 and G120 fractions (glucose concentration at 20 min and 120 min). The tubes were then covered, mixed vigorously on a vortex mixer, and cooled for 5 min in an ice water bath. Subsequently, 7 M KOH solutions (10mL) were added and mixed. The tubes were agitated horizontally for 30 min in an ice water bath. A 0.2-mL portion of the content was pipetted into 1 mL acetic acid 1 M solution after which 40 µl of amyloglucosidase solution was added. The tubes were vortex mixed and transferred to a water bath for 30 min at 70 °C. The tubes were cooled for 15 min in an ice bath and subsequently allowed to reach ambient temperature before adding 12 mL of absolute ethanol. This tube corresponded to the TG (total glucose) portion. Glucose oxidase and peroxidase assay kit were used to estimate glucose concentration of G20, G120, and TG portions using glucose oxidase and peroxidase assay kit GAGO-20 (Sigma–Aldrich, St Louis, MO). Then the availability levels of glucose were estimated.

2.2.3 Protein digestibility

Protein digestibility was assayed using a modified pH-drop procedure as described by Oyeyinka *et al.*, (2016). Ten milliliters of milli-Q water was added to flour samples containing equivalent of 62.5 mg protein. After 1 h at 37 °C, the pH was adjusted to 8.0 with 0.1 mol/L NaOH and/or HCl. A multi-enzyme solution consisting 16 mg trypsin, 31 mg chymotrypsin and 13 mg protease was prepared with pH adjusted to about 8.0. One milliliter of the multi-enzyme solution was added to the 10 mL sample dispersion and pH of the digesta was recorded after 10 min using a pH meter. The change in pH at 10 min of digestion was used to calculate the percent in vitro protein digestibility (IVPD) using the following equation $IVPD = 65.66 + 18.10\Delta pH_{10min}$

3.0 RESULTS

3.1 *In-vitro* starch and protein digestibility of *gari*-enriched with cowpea hull

Starch and protein digestibility is a measure of the amount of protein available from it for absorption after digestion. The in-vitro starch digestibility (IVSD) of the cowpea hull enriched *gari* (CG) is presented in Table 1. The starch digestibility value was lowest CG that were enriched before fermentation (53.37 to 64.22 %). Fermentation might have caused significant ($p < 0.05$) increase in the IVSD of the other CG samples which might be attributed to the restriction of starch caused by the protein in the hull because as the level of hull increased starch digestibility decreased. Also, cowpea hull fermented with cassava mash had increased IVSD than their unfermented counterpart. The reason for the increase can be traced to activities of inherent micro-organism and enzymes present during fermentation which makes starch more accessible to the digestive enzymes (Oyeyinka, 2016).

In-vitro protein digestibility (IVPD) reduced as the percentage of cowpea hulls added is increased and significant improvement in the in-vitro protein digestibility was observed in the fermented cowpea hulls with the cassava mash than their unfermented counterpart. The result negates previous report that fermentation improves the IVPD of maize cultivars

which was attributed to the partial degradation of storage proteins into simple and more soluble products unlike the cowpea hulls which did not have storage proteins like the whole seed grains. Though, the fermented cowpea hulls had improved IVPD than their unfermented counterpart as a result of the reduction in the pH during fermentation which enhance the proteolytic enzyme activity which has been reported to leads to breakdown of proteins to smaller polypeptides which are easily digested (Alloysius *et al.*, 2017).

Table 1: Starch and Protein Digestibility of *gari*-enriched with cowpea hull

Samples	Protein digestibility (%)	Starch digestibility (%)
H ₀ G ₁₀₀	53.37 ^g ±0.01	85.26 ^a ±0.07
CABFH ₃ G ₉₇	58.79 ^c ±0.05	79.01 ^b ±0.01
CABFH ₅ G ₉₅	60.00 ^b ±0.00	75.02 ^c ±0.00
CABFH ₇ G ₉₃	64.22 ^a ±0.01	76.11 ^c ±0.01
CAAFH ₃ G ₉₇	56.02 ^f ±0.01	76.01 ^d ±0.00
CAAFH ₅ G ₉₅	58.23 ^d ±0.17	72.01 ^f ±0.01
CAAFH ₇ G ₉₃	57.42 ^e ±0.01	71.11 ^g ±0.03

Values with different superscript along the column differ significantly by Duncan's multiple range tests at 5% level of significance

Key:

H₀G₁₀₀: Cowpea hull 0%: 100% *gari*

CABFH₃G₉₇: Cowpea hull added before fermentation at ratio 3%: 97% *gari*

CABFH₅G₉₅: Cowpea hull added before fermentation at ratio 5%: 95% *gari*

CABFH₇G₉₃: Cowpea hull added before fermentation at ratio 7%: 93% *gari*

CAAFH₃G₉₇: Cowpea hull added after fermentation at ratio 3%: 97% *gari*

CAAFH₅G₉₅: Cowpea hull added after fermentation at ratio 5%: 95% *gari*

CAAFH₇G₉₃: Cowpea hull added after fermentation at ratio 7%: 93% *gari*

4.0 CONCLUSION

Gari was produced and the effect of enrichment with cowpea hull was significant which affected the starch and protein digestibility of the *gari*. Cowpea hull caused a marked reduction in the starch and protein digestibility. As the level of cowpea hull increases, the starch and protein digestibility decreases. The inclusion of cowpea hull before fermentation gave higher starch and protein digestibility values and sample

CABFH₇G₉₃ (Cowpea hull added before fermentation at ratio 7%: 93% *gari*) initiate the best protein digestibility while CABFH₃G₉₇ (Cowpea hull added before fermentation at ratio 3%: 97% *gari*) had the best starch digestibility.

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**EFFECT OF IN-SITU STORAGE AND FERMENTATION ON THE
FUNCTIONAL PROPERTIES OF THE FLOUR OF AMERICAN YAM BEAN
(*Pachyrhizus Erosus*) TUBERS CULTIVATED IN THE SOUTHEASTEN
NIGERIA**

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One of the most devastating problems affecting African countries in the tropics is Food Insecurity. The study investigated the effect of *in-situ* (underground) storage and fermentation on the functional properties of the flour of American yam bean (*Pachyrhizus erosus*) tubers, planted in Effium, Ebonyi State, Nigeria., for a period of seven months. The fresh tubers after harvest (7 months old) were stored under the ground in a hole dug under a shade, for the period of three months. The hole was 0.5 meters deep and 0.6 meters wide. Samples of fresh and stored tubers were collected every month, hand peeled, washed, sliced, oven dried (55°C/6h), milled and sieved into flour. The flour samples were packaged in a ziplock container, prior to analysis. The functional properties of the flour samples were analyzed using standard methods. Functional properties increased ($P < 0.05$) significantly during three months storage of the tubers while fermentation had variable effects on the properties. From the study, American yam bean (*Pachyrhizus erosus*), a foreign crop to tropical Africa, could be grown in Nigeria. It also revealed that the shelf life of American yam bean tubers, after harvest, could be extended by in-situ storage system, for a period of at least, three months. The functional quality of the flours suggest their possible applications in bakery products, complimentary feeding and as thickening agent in soups.

Keywords: In-situ storage, fermentation, complimentary feeding

Introduction

Among the most devastating problems affecting African countries in the tropics are protein-energy malnutrition and food insecurity (Bhat and Karim 2009). High cost of living, inadequate supply of most staple foods, poor storage conditions and unguided government policies on importation of foods are some of the contributing factors to food insecurity in the African countries (Codex Alimentarius Commission, 2001). *Pachyrhizus erosus* is a legume plant belonging to the genus *Pachyrhizus* and has been shown to be related to soybean and phaseous bean (Leonel and Cereda, 2002). The genus has five (5) species (Zaklan, *et al*, 2007)). Three (3) of these varieties are cultivated species (not wild) and they include *Pachyrhizus abipa* (Adean yam bean), from Bolivia and Northern Argentina, *Pachyrhizus erosus* (Mexican yam bean) from the semi-arid tropics of the central American, Philipines, and West Africa and *Pachyrhizus tuberosus* (Amazonian yam bean) from the tropical low lands of Adean mountain range. Tubers of *Pachyrhizus erosus* much like potatoes cannot be stored for a long time under ambient ($26 \pm 2^\circ\text{C}$) conditions. They have short

shelf life but can keep well in a cool dry place for about two (2) weeks. However, exposures to temperatures below 10°C results in chill-induced changes in colour and texture. Also, prolonged storage under ambient conditions converts its starch into sugar, which makes the tubers less sought for in savory dishes and industrial applications (Ayeh, 2013). This study investigated the effect of storage and fermentation on food quality of this tuber and its flour in Southeastern Nigeria. This will provide valuable information on storage, processing and preservation of the tubers, to enhance food security of many Nigerians.

Materials and Methods

Processing of pachyrhizus erosus flour

This was performed following the method described by Doporto *et al.*, (2011) with some modifications. Freshly harvested tubers were sorted to remove bruised tubers and divided into four portions, which were then assigned to various treatments of 0- month storage (freshly harvested), 1-month storage, 2 months storage, and 3 months storage. The storage system used was *in-situ* (underground). The fresh tubers at the point of harvest (0 month) were washed in water, hand-peeled with knife, and re-washed. Peeled tubers were then sliced to about 3.0mm thickness with the use of a vegetable slicer and shared into two halves of 1 kilogram each. One half (1 kg) of the sliced American yam bean tubers were then oven-dried (model: OVH-102, Nig.) at 55°C for 6 hr. The sample was then milled and the flour obtained and stored in an airtight container for analyses.

The other portion (1 kg) was fermented for 72 hr (3 days). The fermentation type used was solid-substrate-submerged whereby the peeled and sliced tubers were soaked in water as in the case of fermentation of cassava for fufu production. At the end of the fermentation, the fermented tubers was dried at 55°C in the oven (model: OVH-102, Nig.) for 6 hr and milled. The flour obtained was sieved to fine particle and stored in a ziplock container for analyses. These processes and analysis were repeated every month for the other two treatments (unfermented and fermented portions) for a period of three (3) months.

Functional properties determination

Bulk density, gelation temperature, swelling index, WAC and OAC were conducted following the standard methods of Onwuka (2005).

Statistical Analysis

Completely randomized Experimental design was adopted. All determinations were conducted in triplicates. Data generated from laboratory analysis were exposed to two-way analysis of variance (ANOVA), using the Statistical Package for the Social Science (SPSS) (version 20). The mean scores were separated using New Duncan's Multiple Range Test. Significant difference was determined at $P < 0.05$ level of probability

Results and Discussion

Table 1 shows the results on the functional properties of the flours of *Pachyrhizus erosus* tubers after in-situ storage and fermentation of the tubers. The water absorption capacity

(WAC) of *Pachyrhizus erosus* flour ranged from 2.48 to 2.76 mL/g and 2.45 to 2.76 mL/g in the unfermented and fermented samples respectively. These values were significantly ($P<0.05$) higher than the range (0.21 to 0.90 mL/g) reported for unfermented and fermented cocoyam flour (Igbabul *et al.*, 2014). Storage had variable effects on the WAC of the flours as it was found to decrease the WAC value of sample FUT₃ (2.48 mL/g) as well as samples FFT₁ (2.70 mL/g) and FFT₃ (2.45 mL/g). Fermentation resulted in significant decrease ($P<0.05$) in WAC values in all the samples except in FFT₂ (2.76 mL/g). This observed decrease in WAC of the flours due to fermentation was in agreement with the reports of Appiah *et al.* (2011) on fermented breadfruit, *Artocarpus altillis* (Parkinson ex F. A. Zorn Fosberg) pulp flour. The high WAC of the flour samples in this study suggests that flour of *Pachyrhizus erosus* tubers could be made into foods like bread, and other confectioneries (Chandra and Samsher 2013). The OAC of the *Pachyrhizus erosus* flours ranged from 2.71 to 3.46 mL/g and 2.27 to 3.35 mL/g in unfermented and fermented flours respectively. Fermentation caused a significant ($P<0.05$) decrease in OAC of samples FFT₁, FFT₂ and FFT₃. Storage also reduced the OAC of sample FUT₃ and samples FFT₃. The bulk density of samples FUT₂ and FUT₃ as well as FFT₃ were significantly reduced by storage while fermentation on the other hand, significantly decreased ($p<0.05$) the bulk density of the flour samples FFT₀, FFT₁, FFT₂ and FFT₃. The values obtained for swelling index of the flour ranged from 3.80 to 3.91 and 3.62 to 3.78 in unfermented and fermented samples respectively. *In-situ* storage increased swelling index of FUT₁ and FUT₃ (unfermented flours) while it decreased the swelling index of all the fermented flours. The gelation temperature of the flour samples ranged from 78.20 to 82.10 °C which was similar to the range (83.03 to 84.35 °C) obtained for cocoyam flour (Igbabul *et al.*, 2014). With regards to storage, all the flours recorded a decrease ($P<0.05$) in gelation temperature across the period of storage. It was observed that fermentation significantly ($P<0.05$) increased the gelation temperature of all the flours. The increase could be attributed to modifications of starch as a result of fermentation.

Table 1: **Effect of *in-situ* storage fermentation and on the functional properties of flours from tubers**

Samples	WAC (mL/g)	OAC (mL/g)	Bulk density (g/mL)	Swelling Index	Gelation Capacity (°C)
FUT ₀	2.75 ^a ±0.01	3.42 ^a ±0.03	0.565 ^{cd} ±0.003	3.82 ^c ±0.00	79.80 ^d ±0.28
FFT ₀	2.72 ^b ±0.00	3.35 ^b ±0.01	0.562 ^{dc} ±0.000	3.78 ^{dc} ±0.00	82.10 ^a ±0.14
FUT ₁	2.75 ^a ±0.00	3.46 ^a ±0.02	0.565 ^{cd} ±0.000	3.85 ^b ±0.00	78.50 ^e ±0.00
FFT ₁	2.70 ^b ±0.00	3.18 ^c ±0.00	0.560 ^e ±0.000	3.76 ^e ±0.02	80.60 ^c ±0.14
FUT ₂	2.76 ^a ±0.00	3.36 ^b ±0.00	0.569 ^{ab} ±0.000	3.80 ^{cd} ±0.00	78.20 ^e ±0.28
FFT ₂	2.76 ^a ±0.03	3.32 ^b ±0.00	0.554 ^f ±0.000	3.72 ^f ±0.00	81.10 ^b ±0.14
FUT ₃	2.48 ^c ±0.00	2.71 ^d ±0.01	0.573 ^a ±0.001	3.91 ^a ±0.01	77.10 ^f ±0.14
FFT ₃	2.45 ^d ±0.00	2.27 ^e ±0.02	0.568 ^{bc} ±0.000	3.62 ^g ±0.00	80.40 ^c ±0.14

Means ± standard deviation of triplicate determinations. Two means along the same column with different superscripts are significantly different ($P<0.05$).

FUT₀ = flour of unfermented tubers stored for 0 month, **FFT₀** = flour of fermented tubers stored for 0 month
FUT₁ = flour of unfermented tubers stored for 1 month, **FFT₁** = flour of fermented tubers stored for 1 month
FUT₂ = flour of unfermented tubers stored for 2 months, **FFT₂** = flour of fermented tubers stored for 2 months

FUT₃ = flour of unfermented tubers stored for 3 months, **FFT₃** = flour of fermented tubers stored for 3 months

Conclusion

The functional properties, as observed in the study, suggest the possible applications of the flours of American yam bean (*Pachyrhizus erosus*) tubers in bakery, formulation of infant foods, in noodle production and as thickening agent in soups. While it is established from the study, that the crop could successfully be grown in Nigeria, it is recommended that the crop be maximally utilized, to combating the food insecurity in Africa.

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EVALUATION OF DRY MATTER AND PROXIMATE COMPOSITION OF RESIDUE FIBRE FLOUR FROM PROCESSING SELECTED CASSAVA VARIETIES INTO *GARI*

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Abstract

Dry matter and proximate composition of residue fibre flour obtained from processing of cassava roots into gari was studied. Cassava varieties used for the investigation were TME419, TMS30572, NR01/0004, TMS950505, NR87184, Nwageri, Umucass44 and Umucass45. Wet residue fibre from each cassava variety roots were obtained during processing of the roots into gari, dried and milled into flour. Dry matter and proximate composition of each residue fibre flour were determined. There were significant ($p < 0.05$) differences observed in the results recorded. Dry matter was from 92.33 % in NR87184 to 96.35 % in Umucass44. The moisture content ranged from 3.65 (Umucass44) to 7.67 % (NR87184). Nwageri sample was the highest in ash content with the value of 1.75 %, while the lowest value of 0.37 % was recorded in TME419 sample. NR87184 residue fibre flour sample (3.28 %) recorded the highest in crude fibre content and the least 1.82 % in Nwageri sample. Fat content recorded the lowest value of 0.12 % in NR87184 sample and the highest value of 0.411 in TME419 sample. The highest in protein and Carbohydrate's content were in TMS950505 (1.05%) and Umucass44 (92.45%) samples respectively.

Keywords: cassava variety, gari, residue fibre, flour, proximate composition.

Introduction

Cassava (*Manihot esculenta*) is a major staple food in Nigeria and therefore produces large volumes of by-products. Cassava also has to be processed in various ways to reduce its cyanide content to safe levels for human consumption. One of the traditional forms into which the tuber is processed is a granular starchy product called *gari*. In the processing of *gari*, the cassava roots are peeled, washed, grated and dewatered with presses, in this process liquid and solid by-products such as residue fibres are generated.

Residues fibre generated from sieving operation during cassava root processing into gari could lead to reduction in cost of gari and as well as in post-harvest loss of cassava roots (Ohuoba et al., 2019a). The residues fibre from gari processing have very little starch, but high fibre content that could be suitable for consumption by individual that do not need too much starch in their food product (Ohuoba et. al., 2019b). Residue fibre flour had been used to produce fufu and cake (Ohuoba et. al., 2019a&b), thus could be used by people that like little or no wheat in their food products.

Food fibre (complex carbohydrate) is a polysaccharide that cannot be digested in the gastrointestinal track. Fibre has less immediate impact on blood sugar unlike digestible carbohydrates, thereby causing sugar to rise slowly in the blood. Food fibres can be endogenous fibre or added fibre, the former is referred to as intrinsic and intact fibres present in the original food matrix, while the latter is a group of fibres isolated from certain sources and added to a product formulation. These added fibres are called functional fibres (Yao and Andrew, 2017). Food scientists and technologists have joined the research efforts in developing novel functional food products based on the advancement in clinical studies.

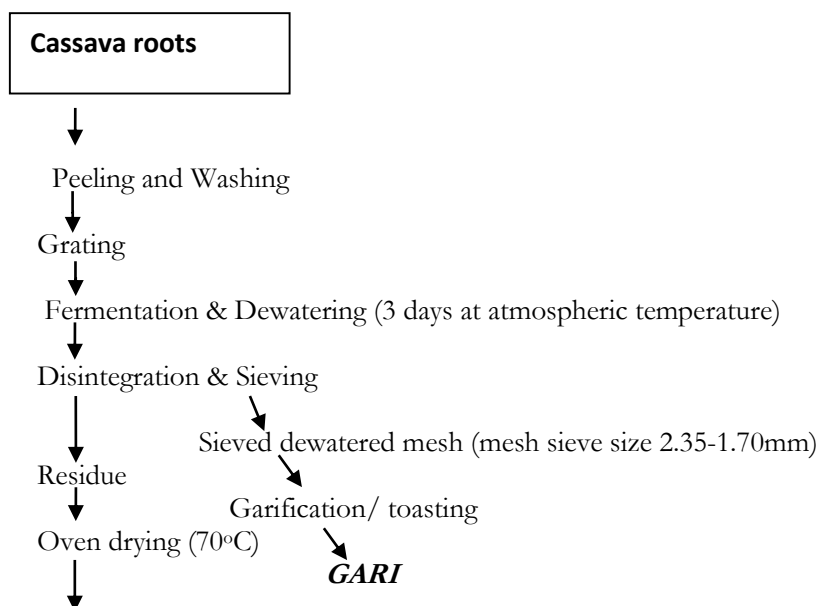
Notably two approaches have been followed: the first one focuses on the full utilization of fibre-rich materials such as whole grains and fibre-rich by-products from fruit and vegetable processing, another direction is to extract and isolate fibre components from various sources (NAS,2001). Residues fibre generated from sieving operation during cassava root processing into gari could be included in the second approach. Functional fibres that are derived from wheat, corn and rice have been commonly accepted in various food applications, both for their health attributes and technical functionalities (Dhingra *et. al.*, 2012).

The yield physical, chemical and the nutrient of cassava flour are influenced by cassava varieties, also the method used in processing the roots affects the final product. Dry matter and proximate composition of gari produced from some cassava varieties root had been documented, however the residue fibre flour and its varietal dependent is yet to be documented. The results that would be obtained from this investigation could be of help to processors and consumers that would like to utilize cassava residue fibre flour from gari processing. Therefore, this study was aimed at evaluating the dry matter and proximate composition of residue fibre flour from processing selected cassava varieties into gari.

Materials and method

Eight cassava (*Manihot esculenta*) varieties roots were used. Six (6) cassava varieties white flesh roots: TME419, TMS30572, NR01/0004, TMS950505, NR87184, Nwageri. Two (2) cassava varieties yellow flesh roots: Umucase44 and Umucase45. These cassava varieties were obtained from the experimental farm of National Root Crop Research Institute, Umudike Abia state, Nigeria.

Each wet solid residues obtained from the cassava gari processing was weighed and dried in an electro thermal oven (model; DHG) at temperature 60 degree Celsius, then weighed again before milling using Thomas Willey mill and Binatone blender model BLG-401. The milled samples were each weighed and sieved with 150 micrometres (μm) aperture sieve to obtain the fine flour. Each sample was packaged with plastic bag labelled and placed in an air-tight plastic container. The flow chart of residue fibre flour obtained from gari processing is shown in figure 1 (Source: Ohuoba *et. al.*, 2019b)



Milling into powder



Residue fibre flour

Figure 1: Flow chart of residue fibre flour obtained from *gari* processing.

(Source: Oluoba *et. al.*, 2019b)

Proximate composition (moisture, crude fibre, ash, crude protein, fat and carbohydrate) and dried matter of the residue fibre flour samples were determined using standard methods, described by Association of Official Analytical Chemistry (AOAC, 2010).

All experiments were carried out in triplicates, data obtained were subjected to one- way analysis of variance using statistical package for social sciences (SPSS) 21.0 for window evaluation version.

Result and discussions

Percentage dry matter and proximate composition of residue fibre flour samples is showed in Table 1. *There were significant ($p < 0.05$) differences observed in the results recorded, which indicated varietal effect on the dry matter and proximate composition of the samples investigated.* The moisture content ranged from 3.65 (Umucass44) to 7.67 % (NR87184). Moisture content is fundamental to the assessment of the nutritional quality of the product being analyzed. The moisture content of food or processed product would have impact on its shelf-life and nutritive value. Low moisture content is a requirement for long storage life of foods, and low levels of the moisture in food products would enhance more concentrated forms of nutrients. The lower the moisture in food products, the more concentrated the nutrients. The lower moisture content is an indication that the residue fibre flour samples will last longer during storage if properly stored under good conditions to prevent absorption of moisture (Iwe *et. al.*, 2017). Variation in results obtained among the different flours could be due to varietal differences and probably environmental factors in areas of cultivation (Alphonse *et. al.*, 2018). The moisture content values are lower than those reported by Abulude and Ojediran (2006) and Idowu *et al.*, (2012) in their respective work on flour samples. Nwageri sample recorded the highest in ash content with the value of 1.75 %, while the lowest value of 0.37 % was in TME419 sample. The ash content of NR01/0004 (0.70 %) and Umucass 44 (0.70 %) samples did not differ significantly ($p > 0.05$). NR87184 cassava variety residue fibre flour sample (3.28 %) was the highest in crude fibre content, while the lowest value of 1.82 % was recorded in Nwageri sample. The crude fibre content of the *gari* residue fibre flour samples were higher than that reported by Nwosu *et al.* (1986), in which the cassava root flour on dry basis was slightly lower than 1.8%. Fat content recorded the lowest value of 0.12 % in NR87184 sample that did not differ significantly with NR01/0004 (0.12%), and the highest value of 0.41 % was in TME419 sample. The highest in protein and Carbohydrate's content were in TMS950505 (1.05 %) and Umucass44 (92.50 %) samples respectively. The results obtained in this investigation could be comparable to the proximate composition results in the work done on cassava flour by Idowu *et. al.*, (2012)

Conclusion

This study shows that the residue fibre (solid wastes) obtained from the sieving operation during cassava roots processing into *gari* could be dried and milled into flour. The results of the proximate composition of the residues fibre flour showed that these flours could be utilized due to their high crude fibre and dry matter, low moisture and fat content which are very good attributes for a stable shelf-life characteristic. In addition, the low-fat content could be good for persons that would want to check their percentage fat in-take. Crude fibre content was observed to be high while moisture and fat was low, thereby giving a good functional and nutraceutical quality. Hence the experimental flour could be used to blend other samples to increase the fibre content and lower their fat content. Furthermore, dry matter and proximate composition results was varietal dependent, thus the study could aid processor and consumer on the cassava variety roots to used based on their specific desired parameter(s).

Table 1: Dry matter and proximate composition of the residue fibre flour samples obtained from processing of cassava *gari* (%)

Sample	Dry matter	Moisture	Ash	Fibre	Fat	Protein	Carbohydrates
	content						
TME 419	94.75 ^c ± 0.001	5.25 ^f ± 0.001	0.37 ^g ± 0.00	2.49 ^d ± 0.00	0.41 ^a ± 0.00	0.62 ^e ± 0.004	90.87 ^c ± 0.004
TMS30572	92.42 ^g ± 0.003	7.58 ^b ± 0.00	0.88 ^e ± 0.00	2.82 ^b ± 0.00	0.19 ^e ± 0.00	0.96 ^b ± 0.001	87.57 ^g ± 0.003
NR01/0004	93.34 ^e ± 0.002	6.62 ^d ± 0.00	0.70 ^f ± 0.00	2.67 ^c ± 0.00	0.12 ^g ± 0.00	0.61 ^e ± 0.002	89.28 ^e ± 0.000
TMS950505	95.34 ^b ± 0.000	4.67 ^g ± 0.00	1.12 ^b ± 0.00	2.01 ^g ± 0.00	0.17 ^f ± 0.00	1.05 ^a ± 0.002	90.98 ^b ± 0.000
NR87184	92.33 ^h ± 0.000	7.68 ^a ± 0.00	0.99 ^d ± 0.00	3.28 ^a ± 0.00	0.12 ^g ± 0.00	0.62 ^e ± 0.002	87.32 ^h ± 0.001
Nwageri	94.05 ^d ± 0.001	5.96 ^e ± 0.00	1.75 ^a ± 0.00	1.82 ^h ± 0.00	0.31 ^b ± 0.00	0.53 ^f ± 0.001	89.64 ^d ± 0.004
Umucass 44	96.35 ^a ± 0.002	3.65 ^h ± 0.00	0.70 ^f ± 0.00	2.23 ^f ± 0.00	0.23 ^d ± 0.00	0.75 ^d ± 0.000	92.45 ^a ± 0.002
Umucass 45	92.79 ^f ± 0.002	7.21 ^c ± 0.00	1.10 ^c ± 0.00	2.35 ^e ± 0.00	0.25 ^c ± 0.00	0.79 ^c ± 0.000	88.31 ^f ± 0.004

Sample means ± standard deviation, Samples means with the same superscript down the columns are not significantly different. (P > 0.05)

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PROXIMATE COMPOSITION OF FOUR CASSAVA GENOTYPE

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ABSTRACT

The cassava (*Manihotesculenta Crantz*) is a starchy root crop cultivated mainly in the tropic and sub-tropic regions of the world which can be consumed fresh or processed for commercial purposes. It is use as food helps to alleviate problem of hunger and carbohydrate intake deficiency. Four cassava breeding lines NR/12/PD/0024, NR/12/PD/0035, NR/12/PD/0036, NR/12/PD/0038 and TME 419 which serves as a check were all bred in National Root Crop Research Institute Umudike. The cassava genotypes were evaluated for its nutritional qualities content. The result showed that moisture content ranged from 63.02 - 74.60 % while other proximate parameters such as ash, fat, fiber, protein and carbohydrate ranged from 0.29 -1.76%, 0.60 – 1.00%, 0.60 - 1.70%, 1.75 - 2.87% and 21.42 – 28.90% respectively. The variations in the quality parameters in the new breeding lines are not too far from the check samples however, the protein and carbohydrate of the check are high compared with the breeding lines.

Key words: Cassava, Genotype, Nutritional composition and TME 419

INTRODUCTION

Cassava is a tuberous crop that belong to the genus *Manihot* species. It is an important staple for over 500 million people in the developing world (Falade and Akingbala 2008). It is an important root crop in many countries both for food security and as a cash crop (Nambisan 2011). It is found to produce reasonable yield even in an infertile soil. The harvesting period is flexible and has been used traditionally as a reserve against natural disaster such as drought (Åkesson 2015). The yield of cassava tuber is influenced by the planting material as well as the agronomic practices adopted (Eze and Ugwuoke 2010). Report shows that tuber yield of cassava is influenced by both the quality of planting material used and the agronomic practices employed. Access to high yielding cassava varieties and an improvement of the production system will result in increased economic benefits to local farmers. Nutritionally it has low content of protein, essential mineral and vitamin and has high starch content. It is accepted as energy giving food because of the carbohydrate content found in its root (Tamasgenet *al.*, 2015)

The objective of this study was to evaluate the nutritional composition of cassava genotype cultivated in National Root Crops Research Institute Umudike

MATERIALS AND METHOD

Four breeding lines of NR/12/PD/0024, NR/12/PD/0035, NR/12/PD/0036, NR/12/PD/0038 and a check; TME 419 were used for the research. They were all bred in National Root Crops Research Institute Umudike. The freshly harvested cassava roots were used for determination of proximate compositions using the method as described by Association of Official Analytical Chemist 2012.

STATISTICAL ANALYSIS

The statistical package IBM SPSS Programme version 20 was used to analyze data. Results were expressed as mean $\pm$ standard error of mean (SEM). One-way analysis of variance (ANOVA) with Duncan post hoc test were used to evaluate the statistical difference between the different groups, the results were considered significance at ($P > 0.05$).

RESULTS AND DISCUSSIONS

Table: 1 Proximate composition of cassava breeding line cultivated in National Root Crops Umudike

Samples	Moisture (%)	Ash (%)	Fat (%)	Crude fiber (%)	Protein (%)	Carbohydrate (%)
NR/12/PD/0024	71.40 $\pm$ 0.20 ^c	0.94 $\pm$ 0.14 ^c	0.75 $\pm$ 0.05 ^b	0.70 $\pm$ 0.00 ^d	1.75 $\pm$ 0.05 ^d	24.10 $\pm$ 0.10 ^c
NR/12/PD/0035	64.40 $\pm$ 0.00 ^d	1.15 $\pm$ 0.15 ^b	0.90 $\pm$ 0.10 ^a	0.80 $\pm$ 0.00 ^c	2.28 $\pm$ 0.00 ^b	27.93 $\pm$ 2.60 ^b
NR/12/PD/0036	74.60 $\pm$ 0.00 ^a	0.50 $\pm$ 0.00 ^d	0.70 $\pm$ 0.00 ^{bc}	1.00 $\pm$ 0.00 ^b	2.00 $\pm$ 0.00 ^c	21.42 $\pm$ 0.22 ^a
NR/12/PD/0038	73.70 $\pm$ 0.10 ^b	0.29 $\pm$ 0.22 ^a	1.00 $\pm$ 0.00 ^a	0.60 $\pm$ 0.00 ^a	1.75 $\pm$ 0.00 ^d	22.35 $\pm$ 0.20 ^d
TME419	63.02 $\pm$ 0.20 ^a	1.76 $\pm$ 0.10 ^a	0.69 $\pm$ 0.10 ^c	1.70 $\pm$ 0.05 ^a	2.87 $\pm$ 0.10 ^a	28.90 $\pm$ 0.35 ^a

Values are mean $\pm$ SD of 3 replications. Means within rows with the same superscripts were not significant difference ($P > 0.05$)

The moisture content of the cassava ranged from 63.02 - 74.60 % while sample TME 419 which is used as the check had the lowest value of 63.02%. The moisture content of the cassava breeding lines which are NR/12/PD/0024, NR/12/PD/0035, NR/12/PD/0036, NR/12/PD/0038 are in line with finding of Ayetigbo *et al.* (2018), whose moisture content ranged from 57.46–75.91%. Freshly harvested cassava is known to be high in moisture and this presupposed its spoilage and susceptibility to microbial attack few hours after harvest (Adepoji and Nwangwu 2010). The differences in the moisture content can be attributed to difference chemical constituent (Chisenga *et al.*, 2019).

The percentage ash content, in food indicates the total mineral content of that sample. The ash content of the cassava breeding line and the check samples is compared with that of Richardson (2013) who reported the ash content of cassava averaging 2.78%. This low ash content is indicative of the low mineral content of cassava (Richardson 2013).

The fat content is in contrast to the value obtained by Salvagor and McCrindle (2014) who suggested 0.1 and 0.3%. The crude protein (1.75 - 2.43 %) is higher than the value obtained by Adepoju and Nwangwu (2010) (0.09%), this can be attributed by the finding of Bechoff *et al.* (2008) who reported that this may probably be related to gene transfer where a cross between wild species and an improved cassava variety resulted in a hybrid that has high protein content. The NR/12/PD/0024 and NR/12/PD/0038 had a lower protein content compared to samples NR/12/PD/0035, NR/12/PD/0036 and TME 419, this might be due to the breeding selection process (Cardoso *et al.*, 2005). The carbohydrate content ranged from 21.24 – 28.90% with average value of 21.50%. The check cassava TME 419 had the lowest value while sample NR/12/PD/00 had the highest value. The carbohydrate content obtained here are compared with that of Richardson (2013) whose values ranged

from 26.28-39.62 %, cassava is regarded as poor in nutrient and has high content of carbohydrate (80–90% dry basis) which is consisting almost entirely of starch (Ayedigbo *et al.*, 2018).

CONCLUSION

Based on the results generated from this study, we therefore, draw our conclusion that the new cassava breeding lines cultivated in NRCRI have higher moisture content compared to the reference cassava TME419. Also, the ash content, is higher than the reference variety. The cassava genotype NR/12/PD/0024, NR/12/PD/0035, NR/12/PD/0036 and NR/12/PD/0038 compete favorably with the reference variety TME 419 as regards to their ash, fat, protein and carbohydrate content.

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**STORAGE STABILITY AND SOME QUALITY ATTRIBUTES OF HIGH
QUALITY CASSAVA FLOURS PRODUCED FROM VARIETIES OF LOW
POSTHARVEST PHYSIOLOGICALLY DETERIORATED
CASSAVA (*MANIHOT ESCULENTA* CRANTZ)**

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Abstract

This study investigated the storage stability and some quality attributes of some quality attributes of high quality cassava flours (HQCFs) produced from varieties of low postharvest physiologically deteriorated (PPD) cassava stored in three packaging materials [low density polyethylene (LDPE), Purdue improved crop storage (PICS) –high density polyethylene (HDPE) bag and plastic container (PC)] for 24 weeks. Cassava roots were processed into HQCFs, analyzed for proximate properties and microbial load at 8 weeks interval. Completely randomized design with fifteen replications was used and data obtained were subjected to general linear model procedure of SPSS (version 25). Mean value from 0 to 24 weeks for moisture, protein, ash, fat, carbohydrate, dry matter and energy content were 7.60 ± 0.67 - 5.53 ± 0.75 %, 0.20 ± 0.07 - 0.17 ± 0.21 %, 0.46 ± 0.20 - 0.44 ± 0.30 %, 0.46 ± 0.20 - 0.32 ± 0.66 %, 91.28 ± 0.73 - 93.55 ± 0.07 %, 92.40 ± 0.87 - 94.45 ± 0.26 % and 1546.50 ± 1.32 - 1581.44 ± 0.04 kJ/kg, respectively. Mean for total viable bacterial and fungal counts ranged from 0.00 to $1.36 \times 10^2 \pm 0.25$ cfu/g and $3.00 \times 10^2 \pm 0.67$ to $1.63 \times 10^2 \pm 0.43$ cfu/g, respectively. HQCFs from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, and IITA-TMS-IBA-011371 cassava were shelf stable and fit for human consumption for 24 weeks at ambient condition in PICS bag, LDPE bag and PC being the most suitable for good product quality.

Keywords: Cassava flour, Storage period, Quality attribute, Microbial quality, Shelf stability

Introduction

Cassava has become a significant food security and industrial crop, contributing as food, feed and industrial biomass in Africa, Asia and South America (Ayetigboet *al.* 2018). Notably, cassava production rose from 132,200,764 tons to exactly 157,271,697 tons in

2010 to 2016, respectively, which was about 18.9% (FAO, 2018). Also, the production share of cassava by region: Africa (60.7%), Americas (9.9%), Asia (29.3%) and Oceania (0.1%) from 2017 to 2018 (FAO, 2020). The total production of cassava in Africa in 2018 was 169,673,737 and Nigeria share in this production was 50,485,047 (FAO, 2020).

Cassava (*Manihotesculenta*Crantz) characteristically has short postharvest “life”and requires quick transportation to point of processing, especially when it is meant for the production of high quality cassava flour (HQCF). The reduced market potential of cassava due to high postharvest physiological deterioration (PPD) phenomenon made stakeholders in its value chain to lose enthusiasm (Rajuet *al.*, 2015; Alimiet *al.*, 2021). Therefore, the development (screening) of some low PPD cassava varieties targeted at extending the shelf life of cassava root from two days (48h) to 5 days (120h) and enhancement of nutritional value such as increased β -carotene (pro-vitamin A), starch, dry matter content, and reduced moisture) is a research development in the right direction in proffering solution to the challenge in cassava value chain (Alimiet *al.*, 2021). Hence, this study examined the effect of packaging materials and storage period on some quality attributes of HQCFs produced from varieties of cassava screened for delayed or low postharvest physiological deterioration (PPD).

Materials and Methods

Materials

Flours from five (5) varieties were used for the study. Four yellow fleshed varieties screened for low postharvest physiological deterioration are: IITA-TMS-IBA011368 (yellow), IITA-TMS-IBA070596 (yellow), IITA-TMS-IBA011412 (yellow), IITA-TMS-IBA011371 (yellow) and one variety of high postharvest physiological deterioration: TMEB419 (white) were provided by International Institute of Tropical Agriculture (IITA), Ibadan.

Production, packaging and storage of high quality cassava flour used in the study

Wholesome cassava roots used for this study was provided by International Institute of Tropical Agriculture (IITA) which were processed into HQCF. The wholesome cassava roots were subjected to unit operations such as peeling, washing in a clean water so as to remove dirt and extraneous material that are adhered to the roots. The washed roots were then grated and pressed with screw jack press to remove water from the mash. The cake was reduced to very small particles (pulverizing) and subsequently dried with the aid of flash dryer at 120 °C for 8 minutes. The flour that was dried using a flash dryer was reduced (milled) to flour using cyclone hammer mill to which a mesh size of 250 μ m was attached. The cooled flours were packaged in (200 g) separately using low density polyethylene (LDPE), plastic containers and purdue improved crop storage – HDPE (PICS) bags under aseptic conditions. The flours from the five different cassava varieties were packed and stored at ambient temperature.

Determination of the proximate composition and microbial assay

The proximate parameters of the HQCFs were determined following the standard analytical procedures (AOAC, 2019). Carbohydrate content in percentage was estimated Nwabueze and Anoruoh, 2011. An equation which was a factor was used in calculating the energy value expressed in KJ/kg (Akubore *et al.*, 2003). The dry matter of the HQCF was estimated as described by Etudaiye *et al.* (2009).

The flours prepared from the clones of low PPD cassava were evaluated for total bacteria and fungi counts. This was carried out using the pour-plate method following International Commission on Microbiological Specifications for Foods (1988) procedure.

Statistical analysis

All experimental data obtained were subjected to the general linear model (GLM) procedure of SPSS (version 25) for the analysis of variance.

Results and Discussion

The range of mean value from 0 to 24 weeks for moisture, protein, ash, fat, carbohydrate, dry matter and energy content were 7.60 ± 0.67 - 5.53 ± 0.75 %, 0.20 ± 0.07 - 0.17 ± 0.21 %, 0.46 ± 0.20 - 0.44 ± 0.30 %, 0.46 ± 0.20 - 0.32 ± 0.66 %, 91.28 ± 0.73 - 93.55 ± 0.07 %, 92.40 ± 0.87 - 94.45 ± 0.26 % and 1546.50 ± 1.32 - 1581.44 ± 0.04 KJ/kg, respectively. The moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination (Kayode *et al.*, 2014). Generally, before storage, the moisture content of the flours prepared from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, IITA-TMS-IBA-011412, IITA-TMS-IBA-011371 and TMEB419 were below the safe moisture level (12-14%) for flour products. Protein, ash and fat contents increased during storage

Table 1: Proximate composition and energy value of HQCFs from low PPD cassava stored for 24 weeks

Variables	MC (%)	Prot. (%)	Ash (%)	Fat (%)	CHO (%)	DM (%)	Energy V. (KJ/kg)
<i>Cassava Varieties</i>							
IITA-TMS-IBA-011368	6.27 ± 0.71^a	0.27 ± 0.20^a	0.76 ± 0.19^{bc}	0.32 ± 0.87^b	92.38 ± 1.38^a	93.73 ± 0.71^a	1563.10 ± 3.23^a
IITA-TMS-IBA-070593	6.28 ± 0.66^a	0.26 ± 0.20^a	0.52 ± 0.30^a	0.46 ± 1.66^a	92.48 ± 1.94^a	93.72 ± 0.66^a	1570.29 ± 3.79^a
IITA-TMS-IBA-011412	7.32 ± 1.27^a	0.27 ± 0.14^a	0.79 ± 0.20^a	0.27 ± 2.61^a	91.36 ± 1.35^a	92.65 ± 1.21^a	1544.44 ± 2.89^a
IITA-TMS-IBA-011371	6.77 ± 0.75^a	0.30 ± 0.21^b	0.57 ± 0.32^a	0.55 ± 1.02^a	91.81 ± 1.51^b	93.22 ± 0.75^b	1563.21 ± 2.58^a
TMEB419	6.65 ± 0.62^b	0.30 ± 0.29^b	0.73 ± 0.17^b	0.37 ± 1.60^a	91.96 ± 1.18^a	93.35 ± 0.62^a	1557.95 ± 2.52^b
<i>Storage period (Weeks)</i>							
0	7.60 ± 0.67^a	0.20 ± 0.07^b	0.46 ± 0.20^a	0.46 ± 0.20^b	91.28 ± 0.73^b	92.40 ± 0.87^a	1546.50 ± 1.32^b
8	7.25 ± 0.55^a	0.51 ± 0.15^a	1.20 ± 0.07^b	0.50 ± 0.17^a	90.53 ± 0.53^a	92.75 ± 0.55^b	1543.55 ± 2.72^a
16	6.86 ± 0.53^b	0.18 ± 0.31^a	0.44 ± 0.15^a	0.33 ± 1.96^a	92.19 ± 2.53^a	93.14 ± 0.53^b	1559.45 ± 3.80^a
24	5.53 ± 0.75^a	0.17 ± 0.21^a	0.44 ± 0.30^a	0.32 ± 0.66^a	93.55 ± 0.07^a	94.45 ± 0.26^a	1581.44 ± 0.04^a
<i>Packaging materials</i>							
PICS	6.58 ± 0.83^b	0.29 ± 0.22^b	0.69 ± 0.15^a	0.38 ± 1.61^a	92.06 ± 2.22^{ab}	93.45 ± 0.83^b	1560.93 ± 3.99^a
LDPE	6.66 ± 0.86^c	0.27 ± 0.19^a	0.67 ± 0.14^a	0.36 ± 1.26^a	92.04 ± 1.92^a	93.34 ± 0.86^b	1559.39 ± 2.02^a
Plastic container	6.44 ± 0.94^a	0.30 ± 0.23^a	0.71 ± 0.14^a	0.42 ± 1.02^b	92.12 ± 2.64^b	93.54 ± 0.91^a	1563.44 ± 4.54^b

NS indicate not significant at $p \leq 0.05$; *** indicate significant effect at $p \leq 0.001$; PICS: Purdue improved crop storage; LDPE: Low density Polyethylene; MC: Moisture content; CHO: Carbohydrate; DM: Dry matter; Prot.: Protein; Energy V.: Energy value

Table 2: Microbiological properties of HQCFs from low PPD cassava stored for 24 weeks

Variables	Total viable bacteria count (cfu/g)	Total viable fungal count (cfu/g)
<i>Cassava Varieties</i>		
IITA-TMS-IBA-011368	1.39x10 ² ±0.57 ^a	1.99x10 ² ±0.58 ^b
IITA-TMS-IBA-070593	1.38x10 ² ±0.60 ^a	2.04x10 ² ±0.46 ^b
IITA-TMS-IBA-011412	1.70x10 ² ±0.70 ^c	2.61x10 ² ±0.48 ^c
IITA-TMS-IBA-011371	1.59x10 ² ±0.66 ^d	1.50x10 ² ±0.33 ^a
TMEB419	1.42x10 ² ±0.60 ^b	1.92x10 ² ±0.53 ^b
<i>Storage period (Weeks)</i>		
0	ND	3.00 x10 ² ±0.67 ^d
8	2.07x10 ² ±0.25 ^d	2.16 x10 ² ±0.44 ^c
16	1.55x10 ² ±0.30 ^c	1.92x10 ² ±0.40 ^b
24	1.36x10 ² ±0.25 ^b	1.63x10 ² ±0.43 ^a
<i>Packaging materials</i>		
PICS	1.67x10 ² ±0.36 ^b	1.94x10 ² ±0.46 ^b
LDPE	1.85x10 ² ±0.37 ^c	2.08x10 ² ±0.46 ^b
Plastic container	1.46x10 ² ±0.36 ^a	1.59x10 ² ±0.42 ^a

NS indicate not significant at $p \leq 0.05$; *** indicate significant effect at $p \leq 0.001$

PICS: Purdue improved crop storage; LDPE: Low density Polyethylene; ND: Not detected

while carbohydrate, dry matter and energy value increased with increasing storage period. The mean values of total viable bacterial and total viable fungal count isolated and identified during the storage of low PPD cassava flour for 24 weeks when stored in different packaging materials are presented in Tables 2. No viable bacterium was detected in the flour samples at day zero (0) when the cassava flours were freshly produced and this could be attributed to the lethal effect of the drying temperature (120 °C) resident in the flash drier preventing their emergence and subsequent growth. The highest total viable bacterial count (1.80 ± 0.14 cfu/g) after 24 weeks of storage was recorded in flour prepared from IITA-TMS-IBA-011371 packed in LDPE. The range of value for the total viable bacterial count in the cassava flours was (0.00 - 1.36) x10²cfu/g while the overall mean value was 1.50 x10²cfu/g (Table 2). The total viable fungal count (TVFC) of the flours

varied significantly ($p < 0.05$) and ranged from 2.00 ± 0.00 - 3.50 ± 0.71 cfu/g, with flour prepared from IITA-TMS-IBA-011371 having the lowest count while the highest count was recorded in flours prepared from IITA-TMS-IBA-011368 and IITA-TMS-IBA-011412, respectively. The highest total viable fungal count (2.40 ± 0.14 cfu/g) after 24 weeks of storage was recorded in flour prepared from IITA-TMS-IBA-011412 (Table 2).

Conclusion

The high quality cassava flours (HQCFs) produced from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, IITA-TMS-IBA-011412, IITA-TMS-IBA-011371 cassava varieties screened for low PPD and TMEB419 (high PPD) were shelf stable (i.e. storage stable) in terms of proximate and microbiological properties and fit for human consumption for 24 weeks (six months) in PICS bag, LDPE bag and plastic container at ambient condition. Plastic container was the most suitable packaging materials recommended for packaging and storing high quality cassava flour produced from low postharvest physiologically deteriorated cassava followed by PICS bag and lastly LDPE for good product quality.

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PROXIMATE COMPOSITION OF YAM FLOUR MODIFIED WITH CASSAVA AND INDUSTRIAL STARCHES TO PRODUCE INSTANT POUNDO YAM FLOUR

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Abstract:

The proximate composition of instant pondo yam and starch blends was evaluated. The yam flour were blended with cassava and industrial starch at varying proportions (100:0, 90:10, 80:20, 70:30, 60:40, 50:50%), with the aim of producing instant pondo yam flour modified with cassava and industrial starch blends. The result obtained shows that there were significance difference in the proximate composition of the mixtures. The moisture content ranged from 4.17-6.89%, crude fibre ranged from 0.80-1.53%, crude protein ranged from 3.35-7.18%, ash content ranged from 0.90-2.35%, fat ranged from 0.93-1.89% and carbohydrate ranged from 81.61- 87.27%.The overall results are indication of good nutritional quality of instant pondo yam flour modified with cassava and industrial starch blends and can be utilized industrially.

Keywords: proximate composition, yam flour, cassava starch, industrial starch

Introduction

Yam (*Dioscorea species*) is an important tropical root crop. Additionally, it is a significant source of carbohydrates for many people in the Sub-Saharan region, particularly in West Africa's yam zone (Akissoe *et.al.* 2003). According to Babaleye (2003), yam provides more than 200 nutritional calories per person per day for more than 150 million people in West Africa and is a significant source of revenue for the region's population. With an annual production of over 28 million metric tonnes, yams are known for their high moisture content, which makes the tubers more vulnerable to microbial attacks and increases their perishability. The crop is crucial for household food security, diet variety, employment and income generation, as well as the reduction of poverty. Instant pounded yam flour is progressively taking the role of the traditionally highly regarded pestle and mortar-based pounded yam processing on the market. According to Alinnor and Akalezi (2010), yam contains about 54% moisture, 1.4% ash, 2.7% fat, 0.087% protein, 0.7% crude fibre, 40.68% carbohydrate and about 731 kj energy.

Instant pounded yam flour is processed quickly and with little energy (Akinoso and Olatoye, 2013). Instant pounded yam flour (IPYF), often known as "pondo yam," is a

dehydrated, white powdery form of yam that is made in a desiccating machine (Ayodeji *et al.*, 2012). Peelings, washing, dicing or slicing, cooking, drying, milling, and packaging are the basic technological processes involved in making instant pounded yam flour. Cassava (*Manihotesculenta*) is a perennial, subtropical crop which is valued for its underground starchy tubers (roots) (Islam *et al.*, 2007). The roots contain, about 1.36 (g) protein, total carbohydrate of 39.06 (g), protein of 1.36 (g), moisture of 69.68 (g), ash of 0.62 (g) and energy of 667 KJ (Salvador *et al.*, 2014).

More than 500 million people in Africa, Latin America, and Asia eat this starchy root crop as their main source of food, and it is primarily farmed in the tropics' hotter lowland areas (Hillocks, 2002).

Cassava starch has some advantages over other starches in the food industry as a texturizer, including being relatively inexpensive, having a low gelatinization temperature, and producing relatively clear, high-viscosity pastes. Its bland flavor also makes it a preferred additive for processed foods with mild flavors (Raphael *et al.*, 2011; Vasconcelos *et al.*, 2016). The aim of this study is to produce instant pondo yam flour modified with cassava and industrial starches and study the proximate composition of the instant poundoyam flour modified with cassava and industrial starch blends.

2.0 Materials and methods

The yam tubers (*Dioscorea rotundata*) locally called white yam and the cassava tubers (*Manihotesculenta*) used for this study was purchased from Kure Market, and the Industrial Starch was purchased from National Board for Technology Incubation all in Minna, Niger State, Nigeria.

2.1 Preparation of Instant Pondo Yam Flour and Cassava Starch

Instant Pondo Yam Flour (IPYF) was produced from the method as described by FIIRO (2005). The yam tubers were chosen, weighed, and then washed to get rid of any adhering sand, mud, or other elements. After being peeled and sliced to a thickness of 0.02 mm, they are dipped in water that included 0.1% sodium metasilicate to stop the browning reaction. The yam tubers were placed in a sieve to remove excess water before being blanched for 10 minutes at 100 °C and dried at 70°C in an oven for 10 hours. Before analysis, the blanched yam slices were grounded, sieved, and packaged in polyethylene bags. The cassava starch was produced from the method as described by Kamaljit K. *et al.*, (2016). Fresh cassava tubers were cleaned, peeled, and cut into roughly 1-cm cubes before being grounded in a high speed blender for 5 minutes. The pulp was agitated for five minutes while being suspended in ten times as much water before being filtered through double-fold cheesecloth. The top liquid was decanted and discarded after the filtrate was left to stand for two hours to allow the starch to settle. Water was added to the sediment, and the mixture was agitated once more for five minutes. The filtrate underwent a second round of filtering as previously, and the starch was allowed to settle. The sediment (starch) was dried at 55°C for one hour after decanting the top liquid. Using a warring blender, instant pondo yam flour (IPYF) and cassava starch (CS), instant pondo yam flour and industrial starch (IS) were combined in various ratios of 90:10, 80:20, 70:30, 60:40, and 50:50%. The label for the flour mixtures read as follows: -YF: (100 % IPYF), YFCS1: (90:10), YFCS2:

(80:20), YFCS3: (70:30), YFCS4: (60:40), and YFCS5: (50:50). YFIS1: (90:10), YFIS2: (80:20), YFIS3: (70:30) YFIS4: (60:40), YFIS5: (50:50). The proximate composition (moisture content, ash content, crude fibre, crude fat, crude protein and carbohydrate) of the samples was determined according to the Association of Analytical Chemists, AOAC (2012) procedures.

3.0 Results and discussion.

The result obtained from proximate composition of sample mixtures are presented in Table 1. The values obtained shows that there were significant difference at $p \leq 0.05$ between all the sample mixtures. The moisture content of the sample ranged between $4.17 \pm 0.17\%$ and $6.89 \pm 0.11\%$. Moisture content for all the samples were below 10% which falls within the safe moisture level for prolong storage of flours. While crude fibre content ranged from 0.80-1.53%, sample YFIS2 having the highest value, however the result fall between the range reported by Udensiet *et al.* (2008). Crude fiber makes stools bulkier and eliminates waste more quickly from the gastrointestinal tract, preventing issues with the digestive system, lowering blood cholesterol, and binding carcinogens Nimenibo-Uadiaet *et al.* (2017). The protein content ranged from 3.35-7.18%, Anuonyeet *et al.* (2014) reported that protein increase in yam/cassava starch blended with soy flour (7.00-12.67) the increase was due to addition of the soy flour. The ash and fat content ranged from 0.90-2.35%, 0.93-1.89% respectively. Ash is substituted for the overall mineral composition of the samples. The findings indicate that the samples may be a source of mineral element with significant nutritional value. Alinnoret *et al.* (2010) Carbohydrate content ranged from 81.61-87.27%. Udensiet *et al.* (2008) reported carbohydrate value for *Dioscoreaalata* ranged from 81.53-87.64% which shows that there was significant $p \leq 0.05$ indicating that all sample are good sources of carbohydrate.

Table 1: Proximate composition of instantpoundo yam flourmodified with cassava and industrial starch blends

Samples	Moisture content%	Crude fibre%	Crude protein%	Ash%	Fat%	Carbohydrate%
YFCS1	6.00 ± 0.01^{cd}	0.81 ± 0.01^b	6.93 ± 0.06^{ab}	2.35 ± 0.05^a	1.68 ± 0.40^{abc}	81.62 ± 0.34^d
YFCS2	5.79 ± 0.19^d	0.97 ± 0.03^b	6.71 ± 0.06^{bc}	1.29 ± 0.01^b	1.08 ± 0.00^d	84.45 ± 0.70^c
YFCS3	4.90 ± 0.10^{ef}	0.83 ± 0.05^b	5.80 ± 0.20^{de}	0.98 ± 0.02^d	1.69 ± 0.31^{abc}	85.78 ± 0.54^b
YFCS4	4.76 ± 0.04^f	1.07 ± 0.03^{ab}	5.60 ± 0.00^{de}	1.51 ± 0.04^c	1.38 ± 0.03^c	85.70 ± 0.05^b
YFCS5	4.17 ± 0.17^g	1.06 ± 0.03^{ab}	5.48 ± 0.14^e	1.00 ± 0.00^d	1.04 ± 0.01^d	87.27 ± 0.05^a
YFIS1	6.16 ± 0.04^c	1.21 ± 0.03^{ab}	7.18 ± 0.17^a	1.93 ± 0.08^b	1.89 ± 0.08^d	81.69 ± 0.01^d
YFIS2	6.78 ± 0.02^a	1.53 ± 0.47^a	7.17 ± 0.18^a	1.53 ± 0.03^c	0.94 ± 0.00^d	81.61 ± 0.15^d
YFIS3	5.99 ± 0.01^c	0.87 ± 0.00^b	6.49 ± 0.15^c	1.50 ± 0.00^c	0.93 ± 0.01^d	84.22 ± 0.17^c
YFIS4	6.89 ± 0.11^a	0.80 ± 0.04^b	5.68 ± 0.08^{de}	0.90 ± 0.01^d	1.65 ± 0.02^{abc}	83.99 ± 0.60^c
YFIS5	6.48 ± 0.08^b	0.99 ± 0.01^b	3.35 ± 0.15^f	1.60 ± 0.10^c	1.78 ± 0.03^{ab}	85.83 ± 0.07^b
YF	5.11 ± 0.11^e	1.05 ± 0.01^{ab}	5.97 ± 0.02^d	1.98 ± 0.01^b	1.51 ± 0.05^{bc}	83.95 ± 0.23^c

Values represent means and standard deviation of triplicate determinations. Mean values with different superscript in a row are significantly ($p \leq 0.05$) different from each other.

KEY: YF= 100% Yam Flour, YFCS1=90% Yam Flour + 10% Cassava Starch, YFCS2= 80% Yam Flour + 20% Cassava starch, YFCS3 = 70% Yam Flour + 30% Cassava Starch,

YFCS4= 60% Yam Flour + 40% Cassava Starch, YFCS5= 50% Yam Flour + 50% Cassava Starch, YFIS1= 90% Yam Flour + 10% Industrial Starch, YFIS2= 80% Yam Flour+ 20% Industrial Starch, YFIS3= 70% Yam Flour + 30% Industrial Starch, YFIS4= 60% Yam Flour + 40% Industrial Starch, YFIS5= 50% Yam Flour + 50% Industrial Starch.

4.0 Conclusion

The present study shows that there are reasonable availability of nutrients in the various sample of flour blends. The findings of this study indicate that the manufacturing of instantpoundo yam flour modified with cassava and industrial starch had a significant impact on the proximate composition. When reconstituted, instant poundoyam flour should possess qualities similar to those of the traditionally prepared, pounded yam that consumers desire and enjoy.

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SOME QUALITY ATTRIBUTES OF STARCHES EXTRACTED FROM SELECTED YAM (*Dioscorea rotundata* and *Dioscorea alata*) VARIETIES IN BENUE STATE.

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ABSTRACT

Starches were extracted from four yam varieties namely; *Amula*(A) and *Hembamkwase* (B) of *Dioscorea rotundata* specie, *Banada* (C) and *Gwebe*(D) of *Dioscorea alata* specie in Benue State. Starches from the yam tubers were analyzed in July for stored yam tubers and designated as A_J, B_J, C_J, and D_J. Freshly harvested yam starches were also analyzed in December designated as A_D, B_D, C_D and D_D. Their yield, amylose and amylopectin content, microstructure and functional properties were analyzed. The percentage yield ranged from 25 to 50% with C_J having the highest yield and A_D having the lowest yield. Microstructure of the starches as examined by scanning electron microscopy (SEM), showed stable granule structures with oval, elongated, round, polygonal and irregular shapes. Amylose content ranged from 26.12 to 33.01%, while amylopectin content ranged from 66.99 to 73.88%. The amylose values of starch from July yam samples were slightly above those from December samples. Solubility and swelling index values ranged from 5.1-7.10% and 5.68 to 8.58g/ml respectively. Bulk density oil and water absorption values were in the range of 0.70-0.92, 0.55-0.75 and 1.30-1.79 respectively. The study concluded that all the yam varieties can be an alternative source of starch for food products based on their unique characteristics they exhibited.

Keywords: Starch extraction, white yam, water yam, microstructure, functional characteristics.

Introduction

Starch is one of the most abundant storage reserved carbohydrates synthesized in many plant tissue including seeds, roots, rhizomes and tubers (1). It is an important raw material used in food and other industries and can be modified to improve its functional properties. Yam is described as an annual or perennial tropical tuber-bearing and climbing plant, that is significantly highly priced starchy crop in West and Central Africa, but is largely underutilized industrially (2). Nigeria is the largest producer of yam accounting for over 70-75% of the world production, however, due to poor shelf life of yam tubers a substantial amount is lost during storage even as most farmers produce yam as subsistence crop (3,4). The high starch content of yam tuber (70-80% dry weight) has made them potential source of starch that could be explored commercially. Lack of adequate information on the extraction and characterization are the limiting factors for its application as a commercial starch. (5), indicated that, for effective utilization of starch in food processing, the starch characteristics such as gelation, retrogradation solubility, visco-elasticity are some of the important information. Such characteristics make appropriate usage of starch to improve

the quality of processed food as expected. Viscosity, gelatinization and texture of starch are influenced by the source of starch, amylose amylopectin ratio (6,7). Starch from different sources show amylose content, gelatinization, granule morphology and starch crystallization differently from each other. For yam starch to be utilized these qualities has to be evaluated. Yam tuber has high starch content and is readily available in Benue State, however, root and tuber crops have low commercial value for direct consumption, so processing yam into starch will make it to have higher economic value.

Material and Methods

The stored and freshly harvested yam tubers were purchased at local market in Makurdi, Benue State. The tubers were peeled, washed, sliced and weighed, wet milled, sieved sediment, and pressed, pressed products were sieved and yam starch was obtained and package in an air tight polyethylene prior to analysis. UV- Visible spectrophotometer was used for amylose determination. AOAC (10) methods were used to analyzed the functional properties of the starches. Scanning Electron Microscopy (SEM), was used to determine the microstructure. Analyses of Variance (ANOVA) using SPSS 13.0 were used to obtain averages of duplicated observation.

Result and Discussion

The total yield of the starch per 1000g slices of the yam values ranged from 25% to 50%. Starch yield and recovery from tuber appeared to be dependent on starch content in the original tuber, and the efficiency of extraction method. Table 1 present the amylose concentration, the values ranged from 26.12% to 33.01% which is considered higher than the normal content that should be 20-25%. The result is an indication of relatively rigid, elastic and strong structure of granules. Figure 1 represents the microstructure of the starches, (the arrangement of phases and defect within a material and is based on cell structure). In this study microscope observation showed that the granules have round, oval ellipse, irregular and spherical shapes. Smaller granules have high molecular bonding, low swelling while large granule size have lower molecular bonding and high swelling. Table 2 present the functional properties of *Amula*, *D.rotundata* had solubility value of 6.25%, 7.10% with swelling index value of 6.99 and 8.58g/ml respectively. *Hembamkwase* of the same specie had solubility of 5.46% and 5.95% with swelling index of 6.47g/ml and 7.93g/ml respectively. The *D.alata* specie had lower solubility values of 5.1, 5.4% for *Banada* and 4.6, 5.6% for *Gwebe*, while the swelling index values were 6.01, 6.95% and 5.68, 5.97g/ml for *Banada* and *Gwebe* respectively. The bulk density values for all the varieties were not significantly different; they ranged from 0.7 to 0.92g/ml/dm³. Oil and water absorption capacity of the samples were distinctive for each variety. Their values within the specie were also significantly different (P<0.05) starch from store *Gwebe* had lowest solubility and swelling index an indication that it contained higher associative forces between the amylose lipid complexes hence high restriction swelling index and solubility are influence by granule size, amylose-lipid complexes, amylopectin structure and extent of interaction between starch chains in the native granule, bulk density gives an indication of the relative volume of packaging material required, it is a physical attribute indicating the ease of transportation and storability. Bulk density, oil and water absorption of the starches were dependent on the varieties

Table 1: Amylose and Amylopectin Content of the Starches Extracted from Four Yam Varieties.

Sample	AM (%)	AMP (%)	AM/AMP
A _J	33.01 ^a ± 0.01	66.99 ^d ± 0.01	0.49 ^a ± 0.001
B _J	28.20 ^c ± 0.34	71.80 ^b ± 0.34	0.39 ^c ± 0.007
C _J	32.24 ^b ± 0.36	67.76 ^c ± 0.36	0.48 ^b ± 0.008
D _J	26.12 ^d ± 0.12	73.88 ^a ± 0.12	0.35 ^d ± 0.002
LSD	0.71	0.71	0.01
A _D	30.98 ^a ± 0.12	69.02 ^c ± 0.12	0.45 ^a ± 0.003
B _D	27.35 ^c ± 0.49	72.65 ^a ± 0.49	0.38 ^c ± 0.009
C _D	30.73 ^a ± 0.32	69.27 ^c ± 0.32	0.44 ^a ± 0.007
D _D	29.63 ^b ± 0.10	70.37 ^b ± 0.10	0.42 ^b ± 0.002
LSD	0.84	0.84	0.02

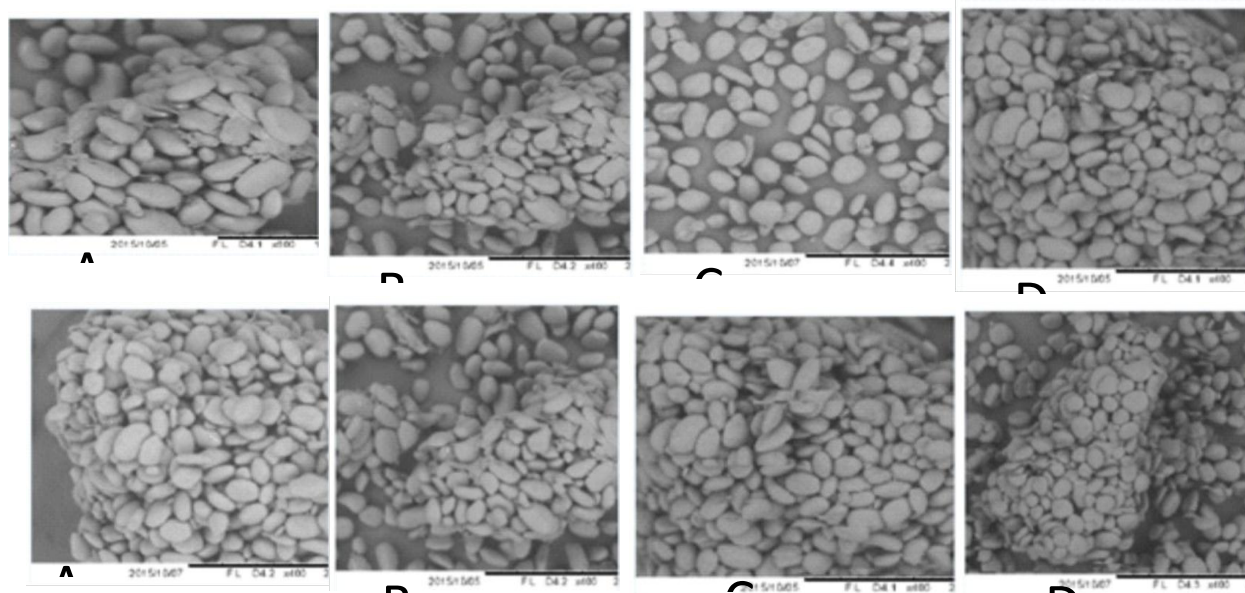
Values are means +/– SD. Means within a column with the same alphabets are not significantly different at $p < 0.05$

KEY: A_J A_D = *Amula*, B_J B_D = *Hembamkwase*, C_J C_D = *Banada*, D_J D_D = *Gwebe*

A_J – D_J represents starch from stored yam, prepared in July

A_D – D_D represents starch from freshly harvested yams prepared in December

AM = Amylose, AMP = Amylopectin, AM/AMP = Amylose/ Amylopectin



KEY: A_J-D_J represents starch from stored yam, prepared in July

A_D –D_D represents starch from freshly harvested yams prepared in December

A_J,A_D=*Amula*, B_J – B_D = *Hembamkwase*, C_J - C_D = *Banada*, D_J- D_D= *Gwebe*.

Fig 1: Microstructure of the extracted starches (Magnification 400x)

Table 2: Functional properties of Extracted Starches from Four Yam Varieties

Sample	S %	SI g/ml	BD g/dm ³	OAC g/g	WAC g/g

A _J	6.25 ^a ±0.50	6.99 ^a ±0.05	0.92 ^a ±0.12	0.67 ^b ± 0.03	1.51 ^c ±0.01
B _J	5.46 ^a ±3.86	6.47 ^b ±0.01	0.89 ^a ±0.03	0.75 ^a ±0.01	1.70 ^b ± 0.01
C _J	5.10 ^a ±3.61	6.01 ^c ±0.02	0.91 ^a ±0.03	0.73 ^{ab} ±0.01	1.41 ^d ±0.01
D _J	4.60 ^a ±0.42	5.68 ^d ±0.12	0.84 ^a ± 0.06	0.58 ^c ±0.04	1.79 ^a ±0.01
LSD	7.39	0.18	0.20	0.07	0.04
A _D	7.10 ^a ±0.02	8.58 ^a ±0.06	0.76 ^{ab} ±0.01	0.55 ^c ± 0.01	1.52 ^b ±0.01
B _D	5.95 ^b ±0.08	7.93 ^b ±0.61	0.81 ^a ±0.03	0.65 ^b ±0.01	1.59 ^a ± 0.01
C _D	5.40 ^b ±0.42	6.95 ^{ab} ±0.10	0.70 ^b ±0.01	0.74 ^a ±0.01	1.30 ^b ±0.01
D _D	5.40 ^b ±0.14	5.97 ^d ±0.11	0.81 ^a ± 0.03	0.55 ^c ±0.01	1.59 ^a ±0.01
LSD	0.63	1.73	0.06	0.07	0.04

Values are means +/– SD. Means within a column with the same alphabets are not significantly different at $p < 0.05$

KEY: A_J A_D = *Amula*, B_J B_D = *Hembamkwase*, C_J C_D = *Banada*, D_J D_D = *Gwebe*

A_J–D_J represents starch from stored yam, prepared in July

A_D–D_D represents starch from freshly harvested yams prepared in December

S = Solubility, SI = Swelling Index, BD = Bulk Density, OAC = Oil Absorption Capacity, WAC = Water absorption capacity

Conclusion

The study has revealed that the four yam varieties yielded starches with appreciable percentages *Banada* D. *alata* specie had the highest yield. Amylose contents of the starches were slightly higher than 25%, microstructure reviewed the irregular shapes of the granules. The attributes reviewed that the starches could be used in diverse food products because of their unique characteristics.

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FUNCTIONAL PROPERTIES AND CHEMICAL COMPOSITION OF WATER YAM-PIGEON PEA FLOUR BLENDS AND SENSORY ATTRIBUTES OF FRIED WATERYAM BALL (*OJOJO*) PRODUCED FROM THE BLENDS

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Abstract

The fortification of water yam ball (*Ojojo*) with Pigeon pea was investigated in order to increase its nutritional value. Water-yam flour and Pigeon pea flour were blended in ratios 100:0, 90:10, 80:20, 70:30 and 60:40 respectively. Functional properties, proximate and anti-nutrients composition of the flour blends were determined using standard methods. A 20-member panel assessed the sensory attributes of fried water yam balls produced from the flour blends, using a 9-point hedonic scale. Water absorption capacity and swelling power of the flour blends increased with increasing pigeon pea, protein contents increased with higher levels of pigeon pea ranging from 3.53% (0% Pigeon pea) to 13.77% (40% pigeon pea) while there is a reduction in fibre contents (1.93 – 1.46%) and ash contents (3.14-2.51%). The phytate and oxalate levels of the sample with 40% pigeon pea substitution were within the acceptable limits. In terms of general acceptability, *Ojojo* produced from 30% pigeon pea (5.6) is next to the sample with 0% pigeon pea flour (8.45) with sample containing 100% most preferred.

Key words: Yam-flour, Pigeon-peas Functional- properties, Chemical-properties, *Ojojo* .

INTRODUCTION

Dioscoreaalata (wateryam) commonly called water yam or “ten month yam” is the most wide spread yam specie and more important as food in West Africa and Caribbean than in Asia and America where it originated (Coursey and Booth, 1997). It possesses higher content of protein, Vitamin. C and low lipid than other species of yam (Muzak- Tuckey, 1993) Pigeon peas (*CajanusCanjam*) is among the dry legumes cultivated for food in Nigeria. Leguminous seeds are important source of plant protein, energy and other nutrient in the diets of large population groups with an excellent source of lysine, methionine, tryptophan, water soluble vitamins (riboflavin, Niacin and Folacin) and minerals (Phophones, iron and magnesium (Ramcharan and Walker, 1985).

Ojojo (Water yam ball) is a delicacy most popular among the people of South-West Nigeria, notably among the Ijebu people. These crispy balls are prepared from freshly grated water yam fried in oil which resemble 'Akara' balls. It is eaten with pap, *Eko*, *Ggari* or as a snack. The objective of this research was to produce nutritious and acceptable water yam ball (*Ojojo*) fortified with pigeon peas to increase its nutritional value.

Materials and methods:

Water yam tubers and pigeon peas were purchased from an open market in Nigeria. All the chemical used for analyses are of analytical grade got from Food Science and Technology Laboratory, Bowen University, Iwo. The method described by Aiyeleye and Eleyinmi (1997) was used to produce white yam flour. The pigeon peas were cleaned and sorted to remove extraneous materials and pressure cooked for 10 minutes. This was followed by dehulling in order to reduce level of anti-nutrients and then washed.

The dehulled pigeon peas were then dried at 60°C for 24 hours after which they were milled. The flour was properly sieved, passed through 60 mesh screen. The yam and pigeon flours were mixed in ratio 100:0; 90:10; 80:20; 70:30 and 60:40 respectively and packed in a polythene bag till used.

Analyses of water yam and pigeon pea flours; functional properties, proximate analyses and anti-nutrients determination were carried out by the method described by Association of official Analytical Chemists (AOAC 2012)

Preparation of water yam ball (*Ojojo*)

One hundred gramme of water yam and pigeon flour was thoroughly mixed with 200mls water to form thick paste, finely chopped onions and pepper were added into the thick paste and also a cube of magi. All the ingredients were mixed together with little salt added. The mixture was fried in balls in deep fat until golden brown colour is obtained. The oil is drained and serve hot to panel members

Sensory evaluation of yam flour balls.

Freshly prepared water yam balls (*Ojojo*) was presented in a small plastic container labelled with three-digit codes to 20 panelists. They were instructed to score the water yam ball sample, using a 9-point hedonic scale.

Data Analysis

Data was analyzed using one way analysis of variance (ANOVA), mean separation was carry out using Duncan New Multiple Range test and SPSS Version 20

Result and Discussion

Table 1: Functional Properties of Water yam(WY)/ Pigeon Pea(PP) Flour Bends

Samples	Parameters		
WY: PP	Bulk density (g/m)	Water absorption capacity (g/g)	Swelling power(%)
100 : 0	0.79±0.00 ^a	2.18±0.21 ^a	2.73±0.29 ^a
90 : 10	0.76±0.05 ^a	2.37±0.24 ^a	2.45±0.94 ^a
80 : 20	0.75±0.11 ^a	2.40±0.08 ^a	2.65±1.14 ^a
70 :30	0.75±0.02 ^a	2.60±0.32 ^a	3.06±0.20 ^a
60 : 40	0.74±0.02 ^a	2.58±0.11 ^a	2.87±0.44 ^a

*Values represent mean ±3 Standard Deviations

*Values with different superscripts along the column are significantly different from each other

The functional properties of the flour blends are shown in table one. Sample containing 40% pigeon pea had the lowest value (0.74g/ml) while sample without pigeon (0%) had the highest value (0.79g/ ml). This is in agreement with the findings of blattackinga and Prakash (1994) who reperted increase in bulk density of flour with increase in starch level.

Water absorption capacity ranged from 2.18g/g (Sample containing 0% pigeon pea flour) to 2.6g/g (Sample with 30% pigeon pea four). This was due to increase in peogeon pea flour with more protein which is responsible for the bulk of water uptake (Afoakwa, 1996). The swelling power ranged from 2.45% to 3.06% for sample with 10% pigeon peas and sample with 30% pea respectively.

Table 2: Chemical Composition of Water-yam(WY)/ Pigeon Pea (PP) FlourBlends(%)

PW:YP	Moisture content	Protein	Fibre	Ash	Fat	CHO	Phytate	Oxalate
100:0	10.66±0.86 ^a	3.53±0.83 ^c	1.93±0.00 ^a	3.14±0.05 ^a	0.63±0.01 ^d	80.77±0.30 ^a	0.15±0.01 ^c	0.20±0.55 ^c
90:10	10.95±2.35 ^a	5.20±0.72 ^d	1.84±0.01 ^b	2.98±0.06 ^{ab}	0.67±0.02 ^c	78.33±1.63 ^b	0.35±0.01 ^d	0.33±0.58 ^d
80:20	11.56±0.37 ^a	7.46±0.45 ^c	1.78±0.01 ^c	2.86±0.12 ^b	0.69±0.06 ^b	75.59±0.30 ^c	0.41±0.01 ^c	0.38±0.46 ^c
70:30	11.95±0.84 ^a	9.69±0.85 ^b	1.62±0.01 ^d	2.68±0.14 ^c	0.77±0.02 ^b	73.22±0.51 ^d	0.62±0.01 ^b	0.42±0.67 ^b
60:40	12.65±0.88 ^a	13.77±1.39 ^a	1.46±0.01 ^e	2.51±0.15 ^d	0.86±0.02 ^a	68.78±1.42 ^e	0.73±0.01 ^a	45.63±0.41 ^a

*Values represent mean ± 3 Standard Deviations

*Values with different superscripts along the column are significantly different from each other

Increase in the level of pigeon pea increased the levels of protein, moisture and fat while decreasing the level of fibre, ash and carbohydrate as expected. The phytate and oxalate levels increased with the increasing levels of pigeon. The level range from 0.15 to 0.73% and 0.20 to 0.45% for phytate and oxalate respectively.

Sensory Evaluation of Fried Water- yam Ball (*Ojojo*) Produced from the Water- yam and Pigeon Flour Blends.

Table 3: Sensory Properties of *Ojojo* Produced from Water- yam(WY)/ Pigeon Pea(PP) Flour Blends

Sample		Variables				
WY:PP	color	texture	Flavor	Taste	appearance	Overall acceptability
100:0	8.35 $\pm$ 0.75 ^a	7.90 $\pm$ 0.91 ^a	8.15 $\pm$ 0.99 ^a	7.95 $\pm$ 0.69 ^a	8.25 $\pm$ 0.85 ^a	8.45 $\pm$ 0.60 ^a
90:10	4.70 $\pm$ 1.34 ^b	5.10 $\pm$ 1.33 ^{bc}	4.85 $\pm$ 1.60 ^{bc}	4.70 $\pm$ 1.56 ^c	4.90 $\pm$ 1.14 ^b	5.10 $\pm$ 1.07 ^b
80:20	4.75 $\pm$ 1.45 ^b	4.65 $\pm$ 1.90 ^c	5.30 $\pm$ 1.56 ^{bc}	4.95 $\pm$ 2.16 ^c	4.70 $\pm$ 1.26 ^b	4.95 $\pm$ 1.43 ^b
70:30	5.10 $\pm$ 1.45 ^b	5.65 $\pm$ 0.99 ^b	5.55 $\pm$ 1.15 ^b	5.95 $\pm$ 1.00 ^b	5.10 $\pm$ 1.29 ^b	5.60 $\pm$ 0.94 ^b
60:40	4.75 $\pm$ 1.72 ^b	4.45 $\pm$ 1.88 ^b	4.50 $\pm$ 1.61 ^c	5.20 $\pm$ 1.64 ^{bc}	4.65 $\pm$ 1.63 ^b	5.05 $\pm$ 1.47 ^b

*Values represent mean ± 3 Standard Deviations

*Values with different superscripts along the column are significantly different from each other

In terms of colour texture, taste and appearance there were a significant difference among the samples containing 100% water yam flour and samples with 20%, 30% and 40% pigeon pea; colour ranged from golden brown to light brown, with sample containing 100% water yam most preferred. In terms of general acceptability, sample with 30% peas was the most preferred among the blends, while sample with 0% pigeon pea had the highest overall acceptability.

Conclusion;

The addition of pigeon pea flour to water yam flour for making ojojo increased the protein level of the product. *Ojojo* produced from 30% pigeon peas substitution level was preferred to the ones from other blends by the panelists.

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EVALUATION OF CHEMICAL COMPOSITION AND SENSORY PROPERTIES OF *ESIKOLO* SUPPLEMENTED WITH SOYBEAN (GLYCINE MAX) AND PLANTAIN (*MUSA SPP*) FLOURS.

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ABSTRACT

Esikolo is a traditional food which is eaten as a staple food in Edo state of Nigeria. It is prepared from grated water yam and plantain. The main objective of this study was to fortify *Esikolo* with soybeans protein. Grated wateryam, plantain and soybeans flours were blended together in ratios 70:15:15, 65:25:10, 60:35:15 and 100:0:0 respectively. Proximate, antinutrients, minerals compositions and sensory attributes were determined, using standard methods. The ranges of values obtained were 7.78-6.27% (moisture), (30.82-5.65%) (protein); 3.74-2.62% (ash); 15.76-0.54% (fat); 19.81-1.69% (fibre); 83.23-34.25% (carbohydrates) 270.58-58.50 ppm (iron); 9.44-4.24ppm (copper); 285.34-243.7 (magnesium); 140.41-43.04ppm (calcium); 1093.15-1010.20ppm (potassium); 0.43-0.16% (phytate) and 0.18-0.14ppm (oxalate). Inclusion of soybeans and plantain in the formulation increase the nutritional status of *Esikolo*. The most acceptable sample among the blends was the sample containing 70% waer-yam, 15% soybean and 15% plantain. The product containing 100% water- yam was the most preferred sample in terms of general acceptability.

Key words: *Esikolo*, fortification, soybean, plantain, properties

INTRODUCTION

Water yam produces tubers that are white, brownish red in colour (Obidiegwu, Asiedu, Ene-Obona, Muoneke and Kolesnikowa-Allen (2009:132) with high water content (70%) and more nutritious than other yam species (Osagie, 1992:240). It is usually eaten in various other value-added food forms such as *Esikolo* in order to improve staple food supply. *Dioscorea alata*, because of its low sodium and high potassium and TDF contents, is eaten to manage related chronic diseases (Dufie, Oduro, Ellis, Asiedu, and Maziya-Dixon 2013:497). Soybeans contain 40% high quality protein and a good balance of amino acids and have therefore tremendous potential to improve nutritional status of consumers (Osho, 2003:280). *Esikolo* is prepared with grated water yam, plantain and spices, wrapped with *Thaumatococcus damellii* leaves, steamed and consumed as a main diet. The aim of this project is to fortify *Esikolo* with soya bean to improve its nutritional quality.

Materials and Methods:

Materials

Water yam, unripe plantain, soya bean and all other ingredients were procured from Bodija market in Ibadan. Equipment and analytical chemicals were obtained from the laboratory of Food Science and Technology Programme in Bowen University, Iwo, Nigeria.

Methods

Production of grated water yam

Water yam tubers were cleaned, peeled and cut into thin slices so as to ensure efficient heat circulation during blanching and drying. Slices were washed, weighed and treated with 0.75% of sodium metabisulphite to prevent browning. Yam slices were drained, rapidly blanched at 100°C for 5 minutes and grated.

Production of Plantain flour

Unripe plantains were washed and the skin were peeled, cut into slices, washed, blanched for 15 mins in water at 100°C, dried for 4 hours at 50°C, milled and packed in zip locks until used.

Production of soya bean flour

Soya bean was cleaned to remove extraneous materials and soaked in tap water overnight. It was dehulled, washed, dried at 55°C for two hours, milled and packaged in zip lock.

Formulation of blends of water yam, soybean and plantain

Grated water yam, plantain and soya beans flours were mixed/blended together in ratios 70:15:15; 65:25:10; 60:35:5 and 100:0:0 respectively.

Production of *Esikolo*

Dry ingredients were mixed in a mixing bowl for 5 minutes with addition of small quantity of water. The thick paste obtained was wrapped in leaves, put on a tray and boiled in an aluminium cooking pot to obtain a paste (*Esikolo*). The product were packed into different zip-lock bags, kept at room temperature for analysis.

Analyses of Samples

Proximate, mineral and antinutrients analyses of the sample were carried out using the method described by AOAC (2019:923.03, 923.05:). 15-member panelists who were familiar with the product were used for the sensory evaluation. Data was analyzed using one-way analysis of variance (ANOVA). Mean separation was done by Duncan's new multiple range test, using SPSS (Version 20).

RESULTS AND DISCUSSION

Table 1 showed the result of chemical composition of *Esikolo*; Ranges of values obtained were 7.78-6.27% (moisture), (30.82-5.65%) (Protein); 3.74-2.62% (Ash); 15.76-0.54% (Fat); 19.81-1.69% (Fibre); 83.23-34.25% (Carbohydrates) 270.58-58.50 ppm (iron); 9.44-4.24ppm (Copper); 285.34-243.7 (Magnesium); 140.41-43.04ppm (Calcium); 1093.15-1010.20ppm (Potassium); 0.43-0.16% (Phytate) and 0.18-0.14ppm (oxalate). Protein, fat,

Ash, fibre and minerals levels increased with increase in level of soybean while the carbohydrate level decreased. The results obtained were in agreement with the findings of Osho (2003:280). Increase in the level of plantain also increased potassium contents of *Esikolo* samples significantly.

Table 1: Chemical Composition of *Esikolo* from Water yam (WY) Soybean(SY) and plantain flours(PL)

WY:SY: PL: (ratios of blending)

Parameter	70:15:15	65:25:10	60:35:5	100:0:0
Moisture (%):	7.78±0.17 ^c	6.63±0.25 ^b	6.70±0.20 ^{ab}	6.27±0.20 ^a
Protein (%):	19.65±0.44 ^b	24.80±0.10 ^c	30.82±0.10 ^d	5.65±0.12 ^a
Fat (%):	8.53±0.37 ^b	13.23±0.23 ^c	15.76±0.15 ^d	9.54±0.41 ^a
Ash(%):	2.89±0.10 ^a	2.76±0.12 ^a	3.74±0.18 ^b	2.62±0.12 ^c
Fibre(%):	5.87±0.15 ^b	8.79±0.16 ^c	9.80±0.10 ^d	1.69±0.05 ^a
Carbohydrate (%):	55.25±0.36 ^c	42.76±0.60 ^b	34.25±0.13 ^a	83.23±0.30 ^d
Phytate(%):	0.43±0.05 ^a	0.40±0.36 ^a	0.46±0.01 ^b	0.16±0.01 ^a
Oxalate(%):	0.14±0.76 ^a	0.18±0.33 ^b	0.37±0.31	0.21±1.04 ^c
Iron(ppm):	270.58±58.50 ^a	207.18±23.37 ^a	253.00±6.75 ^a	141.23±69.89 ^a
Copper(ppm):	6.67±2.5 ^a	4.24±0.58 ^a	9.44±4.44 ^b	4.24±0.58 ^a
Magnesium (ppm):	250.75±1.73 ^a	265.50±0.77 ^a	285.34±2.63 ^a	243.70±30.05 ^a
Calcium (ppm):	96.80±10.14 ^b	118.03±2.37 ^{bc}	140.41±4.47 ^c	243.04.20.17 ^a
Potassium (ppm):	1014.81±16.39 ^a	1065.15±1.56 ^a	1093.15±94.39 ^a	1010.20±5.44 ^a

* Samples with the same superscripts along the row indicates that there is no significant difference among samples at 5% level of significance.

* Values represents means ± 3std deviations.

Table 2 showed the result of sensory evaluation of *Esikolo* produced from blends of water yam, soybean and plantain flour. In terms of colour, sample with 100% scored the highest (7.27) while the sample containing 70% water-yam scored the lowest (5.67). For appearance, taste and aroma there were no significant differences among the replicates ($P > 0.05$). In terms of texture, sample with 100% yam-flour. scored the highest (6.67), while the sample containing 70% yam-flour scored the lowest value of 5.27. *Esikolo* from the flour blend containing 70% yam flour, 15% soya bean and 15% plantain were the most preferred of all the blends. In terms of general acceptability, sample with 100% water-yam, was the most preferred of all the samples..

Table 2: Sensory Evaluation of *Esikolo* produced from blends of water yam (WY), Soyabean (SB) and plantain (PL:) Flours

Blending ratios (WY: SB: PL)

parameter	70:15:15	65:25:10	60:35:15	100:0:0
colour:	5.67±1.54 ^b	5.33±1.76 ^b	5.47±1.92 ^b	7.27±1.76 ^a
Taste:	5.27±1.87 ^a	5.27±1.39 ^a	5.67±1.68 ^a	6.33±1.29 ^a
Aroma:	5.93±1.39 ^a	5.80±1.26 ^a	6.00±1.46 ^a	6.47±1.85 ^a
Texture:	5.27±1.03 ^b	5.33±1.35 ^b	5.13±1.99 ^b	6.67±1.54 ^a
Appearance:	4.87±1.25 ^b	5.27±1.44 ^b	4.93±1.62 ^b	6.80±1.32 ^a
General Acceptability:	5.47±1.64 ^b	5.40±1.40 ^b	5.27±1.71 ^b	7.13±1.59 ^a

* Values represents means ± 3standards Deviations.

* Samples with the same superscripts along the row indicates that there is no significant difference among the samples at 5% level of significance.

Conclusion

Inclusion of soybeans and plantain in the formulation increase the nutritional status of *Esikolo*. The most acceptable sample among the blends was the sample containing 70% waer-yam, 15% soybean and 15% plantain. Theproduct containing 100% water- yam was the most preferred sample in terms of general acceptability.

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CHAPTER 5

FRUITS AND VEGETABLE PROCESSING

ASSESSMENT OF THE CHEMICAL AND ANTIOXIDANT PROPERTIES OF SELECTED TOMATO PASTE SOLD IN UMUAHIA METROPOLIS

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Abstract

This work evaluated the chemical and antioxidant properties of five selected tomato paste products (nicknamed SON, GEN, SUD, STA and CLA) sold in Umuahia Metropolis. The antioxidant activity and chemical parameters were determined by standards methods. The results showed that lycopene (4.20mg/100g), vitamin C (12.76mg/100g) and vitamin A (1.43mg/100g) were significantly ($p < 0.05$) higher in STA tomato paste. Beta carotene (3.02mg/100g) and vitamin E (11.14mg/100g) were significantly ($p < 0.05$) higher in CLA paste, while phenol (3.28mg/100g) was significantly ($p < 0.05$) higher in SUD paste. Stronger antioxidant activity was observed in SON paste for DPPH (62.07%), ABTS (41.00%) and FRAP (47.88%), respectively. The result revealed that SON tomato paste was the best in most of the measured variables than other paste. From the antioxidant activity and chemical results, these tomato pastes can boast physiological health against degenerative disorders.

Keyword: Umuahia metropolis; Tomato paste; Chemical properties; Antioxidant properties

Introduction

Tomato (*Lycopersicon esculentum*) is an annual vegetable commonly consumed world-wide. Tomato is consumed raw, in salads, or after cooking. Due to its high perishability, much wastage is recorded in fresh tomato fruit yearly [1]. Processing operations such as concentration and heat treatment have been applied to ensure their availability all year round. Tomatoes, either in fresh and processed form possess high nutritional values, due to its vitamins, folates, carotenoids and phenolic compounds [1]. Tomatoes contains other natural antioxidants, including ascorbic acid and phenolic compounds (phytochemicals). Dietary intake of tomato products has been shown to decrease the risk of chronic diseases like cancer (breast, colon, prostate) and cardiovascular diseases [2]. As much as the health benefit of tomato consumption is concerned, adulterated tomato pastes that posits great economic losses and possible food toxicity have entered the market place [3]. Studies which examine the chemical and antioxidant properties of different tomato brands sold in Nigeria, and by extension, Umuahia metropolis are limited. Therefore, the aim of this study was to assess the antioxidative qualities of selected tomato paste sold in Umuahia Metropolis.

Materials and Methods

Five different brands of tomato paste sold in Ubani market, Umuahiametropolis were identified and used for the analysis. The selected tomato brands were those registered with the National Agency for Food and Drug Administration and Control (NAFDAC). The manufactured and expiry dates, country of origin and batch numbers of tomato paste products was also noted. The tomato pastes were analyzed for lycopene, phenols, carotenoid, tocopherol, ascorbic acid and vitamins A and E according to standard methods of AOAC [4]. The antioxidant activities were evaluated by ABTS, DPPH, FRAP assays according to the methods of Seeram et al., Manzocco et al. and Benzie and Strain [5, 6&7].

Statistical analysis

The statistical analysis was done in duplicates using the statistical package for social sciences, version 23.0 for windows. One way analysis of variance (ANOVA) was used for comparison of the mean at $p < 0.05$ significant level using Duncan multiple range test.

Results and Discussion

Chemical properties of tomato paste sold in Umuahia Metropolis

Table 1 shows the chemical properties of tomato paste sold in Umuahia Metropolis. The results revealed significant variations ($p < 0.05$) in the chemical constituents of the tomato paste samples. Lycopene (4.20 mg/100g), vitamin C (12.76mg/100g) and vitamin A (1.43mg/100g) were higher in STA paste. On the hand, beta carotene content (3.02 mg/100g) and vitamin E (11.14 mg/100g) were higher in CLA, while vitamin E (11.14 mg/100g) was higher in GEN. These values are within the range reported by Onyeaghalae et al. [8] on tomato paste. The results showed that the tomato pastes are rich sources of antioxidant compounds which can scavenge free radicals *in vivo* and boast physiological health to consumer [2]. This is as a result of the presence of antioxidant compounds like phenol, lycopene, flavonoid, beta carotene and the vitamins, A, C and E in the tomato paste. It is desirable as they are known to pose health benefits including antioxidant activity and immune-competence *in vivo*. The lycopene constituent of tomato and tomato products has been found to prevent prostate cancer [9].

Table 1. Chemical properties of tomato paste sold in Umuahia Metropolis

Tomato Type	Lycopene mg/100g	Carotene mg/100g	Vit. C mg/100g	Vit. A iu/100g	Vit. E mg/100g
SON	4.12 ^a ±0.11	2.18 ^c ±0.03	11.88 ^b ±0.38	1.23 ^c ±3.58	9.91 ^d ±0.02
GEN	3.45 ^c ±0.04	1.96 ^d ±0.05	11.24 ^c ±0.10	1.39 ^b ±6.20	11.14 ^a ±0.14
SUD	2.95 ^d ±0.04	2.49 ^b ±0.46	12.08 ^b ±0.10	1.30 ^c ±3.05	10.76 ^b ±0.18
STA	4.20 ^a ±0.49	2.17 ^c ±0.01	12.76 ^a ±0.16	1.43 ^a ±6.15	10.41 ^c ±0.04
CLA	3.94 ^b ±0.49	3.02 ^a ±0.14	10.50 ^d ±0.05	1.28 ^d ±3.58	11.14 ^a ±0.25

Values show means of triplicate analysis to standard deviation. Different alphabets in

the
same columns are significantly different (P<0.05).

Antioxidant activity oftomato pastes sold in Umuahia metropolis

Results of antioxidant activity of the tomato paste sold in Umuahia metropolis are shown in Table 2.It showed that all the tomato paste demonstrated strong antioxidant activity. The scavenging activity of the %DPPH, ABTS and FRAP of tomato paste extracts rangedfrom 48.69% to 62.07%, 35.28 to 41.0% and 41.39 to 47.88%,respectively. The results showed that SON tomato paste demonstrated the highest antioxidant activity than other tomato pastes. The phenol content ranged from 2.33 to 3.28 mg/100g, while flavonoids ranged from 0.17 to 0.25%. STA tomato paste revealed the least concentrations of phenols and flavonoids. Given the concentrations of the antioxidant constituents in the tomato paste, the scavenging activity of DPPH, ABTS and FRAP assays were directly contributed by the antioxidant constituents. The same finding was observed by [10] on tomato products. The overallresult exhibited high levels of antioxidant compounds:phenols, carotenoid, lycopene, flavonoids, vitamins A, C and E. These compounds are protective to the cellular tissuesagainstoxidative damage and stress [2]. Often, tomato paste is used as food colorant in soups, stews and/or sauces, its importance as a functional food for the boasting of physiological health of consumers cannot be over-emphasized.

Table 2. Antioxidant activity oftomato pastes sold in Umuahia metropolis

Tomato Type	DPPH (%)	FRAP (%)	ABTS (%)	Phenol (mg/100g)	Flavonoids (%)
SON	62.07 ^a ±0.28	47.88 ^a ±1.51	41.00 ^a ±1.28	2.56 ^b ±0.66	0.23 ^a ±0.01
GEN	57.77 ^b ±0.84	45.46 ^b ±0.64	40.71 ^a ±0.63	2.78 ^b ±0.09	0.25 ^a ±0.01
SUD	55.53 ^c ±1.02	44.06 ^c ±0.07	38.55 ^b ±0.51	3.28 ^a ±0.19	0.21 ^{ab} ±0.03
STA	57.59 ^b ±1.06	43.70 ^c ±0.07	35.28 ^c ±0.14	2.33 ^c ±0.16	0.17 ^c ±0.01
CLA	48.69 ^d ±0.03	41.39 ^d ±0.06	38.74 ^b ±0.32	2.82 ^{ab} ±0.46	0.23 ^a ±0.01

Values show means of triplicate analysis to standard deviation. Different alphabets in
the
same columns are significantly different (P<0.05).

Conclusion

The results showed that the brands of tomato pastesold in Umuahia metropolis contains diverse health promoting constituents including phenolic, flavonoid, carotenoids, vitamin A, C and E, all of which possess antioxidant properties. However, SON tomato paste had stronger antioxidant activity than other pastes.

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ASSESSMENT OF PASTING PROPERTIES AND ANTINUTRITIONAL FACTORS OF AERIAL YAM AND COCOYAM COMPOSITE FLOURS

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ABSTRACT

Aerial yam (*Dioscorea bulbifera*) bulbs and cocoyam (*Xanthosoma sagittifolium*) corms were processed into aerial yam flour (AYF) and cocoyam flour (CF) respectively and used to formulate composite flour blends in the ratio AYF:CF; 100:00, 90:10, 80:20, 70:30, 60:40 and 50:50. The 100% aerial yam flour served as control. The pasting properties and the antinutritional factors were determined using standard procedures. Results of the pasting properties indicate that the composite flours containing 10% cocoyam flour were comparable to other blends in terms of final and setback viscosities. The pasting temperature did not differ significantly ($P \geq 0.05$) within the composite blends and the 100% aerial yam. The results of the antinutritional factors showed that phytate, saponin, tannin, oxalate and cyanide were low and fall within the acceptable limits for consumption. The study concluded that the composite flours may find relevance in food applications as food thickeners and consumption as stiff porridge especially in developing countries.

Keywords: Aerial yam, Cocoyam, Pasting properties, Antinutritional factors, flour blends

INTRODUCTION

Aerial yam (*Dioscorea bulbifera*) is an unpopular bulbil bearing, fast-growing variety of yam species with good source of calories and minerals such as iron, calcium and phosphorus among the edible yam (Nwosu, 2013). Aerial yam, also known as air potatoes is grown for some regions of Nigeria its bulbils are eaten during the famine season. Cocoyam is the third most important root and tuber crop in Nigeria following yam and cassava though consumption of cocoyam is assumed to be for low income earners of the society in some communities, because it is readily available at a relatively lower price (Amadi *et al.*, 2017). Cocoyam is grown for its edible roots though some hard-to-cook property has limited the consumption. Cocoyam corms generally have been noted to contain anti-nutrients. It is an underutilized tropical root plant in Nigeria, its utilization is still at the subsistence level, making it a highly neglected crop. Aerial yam and cocoyam are unpopular, one of the reasons being the presence of toxicants. Therefore, they are less studied, underutilized both at subsistence and commercial levels, and have received minimal interest and attention by food processors. In Nigeria, aerial yam and cocoyam are used as nutrition therapy management of some ailments like diabetes (Igbokwe *et al.*, 2017; Kalu *et al.*, 2021). The plant does not just serve as energy food but are also rich in phytochemicals which can be used for human wellbeing. However, the level of these antinutrients in food is important due

to their adverse effects. They limit the availability of nutrients such as copper, iron and zinc in food. In some cases, antinutrients for example, tannins can also bind to toxic metal ions (heavy metals), reducing their absorption and therefore exerting a positive effect on health. Variations in the concentration of these antinutrients in plants differ with the specie, cultivar and processing methods. Therefore, processing such crops into flours will reduce post-harvest losses and characterizing the flour blends based on pasting profile could help complement other efforts been made to increase their usage, popularize and enhance the use of these food crops among the populace.

MATERIALS AND METHODS

Aerial yam (*Dioscorea bulbifera*) bulbs and cocoyam (*Xanthosoma sagittifolium*) corms were purchased from Gboko Main Market, Benue state, Nigeria and Kure Ultra-modern Market, Minna, Niger State Nigeria respectively. Both were transported to the Laboratory using jute bags. The aerial yam (AYF) and cocoyam flours (CF) were prepared and formulated into blends (AYF:CF) at ratios 100:00, 90:10, 80:20, 70:30, 60:40 and 50:50. Rapid Visco Analyzer (RVA), as defined by Newport Scientific (1998), was used to determine the pasting parameters. In the RVA container, 3 g of the various flour blends was mixed with 25 mL of distilled water to make slurry. The canister was lowered into the system after being placed in the tower. The slurry was heated to 95 °C for 14 minutes and then cooled to 50 °C. The peak, trough, final, breakdown, and setback viscosities were calculated, together with the pasting temperature and time to reach peak viscosity. The antinutritional factors: phytate, cyanide, tannin, saponin and oxalate were determined using the methods as described by Wada *et al.* (2019).

Statistical Analysis

Experiments were conducted in triplicates. One-Way Analysis of Variance (ANOVA) and Duncan Multiple Range Test at 5 % level of significance were performed using SPSS software version 23 to evaluate differences in data obtained for the flour blends

RESULTS AND DISCUSSION

The pasting properties of the cocoyam and aerial yam flour blends samples are presented in Table 1. Pasting property is one vital functional property which measures the ability of flour to form a paste. It dictates the textural integrity of products and the quality of flour (Adebowale *et al.*, 2008). The peak viscosity (PV) is the maximum viscosity a flour can reach before collapsing ranged from 2357.67 to 3085.33 cP while the trough viscosity (TV) which reflects a paste's ability to survive breakdown when heated, ranged from 2088.33 to 2544.33 cP. The 100 CF had the highest value and 60AYF:40CF the lowest. The breakdown viscosity (BV) demonstrates the paste's resistance to shear stress as well as its stability under thermal treatment (Falade and Okafor, 2015). The flour samples had BV ranging from 93.00 to 997.00 cP. Lower BV determines the paste's resistance to heat and shear disruptions, which is critical in determining paste stability (Adebowale *et al.*, 2008). These results suggest that 100 % CF and the composite flour samples with the low breakdown viscosities are more likely to

tolerate high heat treatments, shear stress, hence paste stability and these would be better suited for use in products that require high-temperature treatment. Final viscosity (FV) of the flour samples also ranged from 3014.00 (100CF) to 3998.66 cP (100AYF). FV describes the viscosity of the paste after the entire cooking and cooling process or the viscosity in actual use (Oyeyinka *et al.*, 2020), it could ensure a consistent stability of products when used as a food ingredient for thickening and stabilizing roles. According to Falade *et al.* (2015) a high setback viscosity suggests a lesser susceptibility to retrogradation. The highest setback value was recorded for 100% AYF. High setback indicates that these could be used in products that require cold temperature storage as well as for making pasta and some highly viscous local delicacies like *fufu*. Pasting time and temperature ranged from 4.87 (100 CF) to 7.00 min (60AYF:40CF) and 85.37°C (100 CF) to 86.60°C (50AYF:50CF) respectively. These findings are consistent with the study of Oyeyinka *et al.* (2020), which suggested that peak viscosity and pasting time and temperature are inversely proportional, meaning that higher peak viscosities have lower pasting times and temperatures.

The results for the antinutritional factors are as presented in Table 2. The most abundant of the antinutrients in the flour samples were saponin which ranged between 36.21 (100AYF) and 26.56mg/100g (100CF), followed by cyanide which ranged from 29.96 to 13.26 mg/100g (100AYF). Oxalate which ranged from 8.00 to 9.03mg/100g was the lowest in all the samples. Phytate ranged from 10.10 to 23.87 mg/100g while tannin ranged between 15.06 to 18.44 mg/100g. The cocoyam flour had the lowest value of saponin, phytate and tannin while the aerial yam flours had higher values. Therefore, composites of aerial yam and cocoyam flours may help lower the risk of antinutrients in food processing and applications. There was a significant ($p < 0.05$) difference among the samples. However no significant ($p < 0.05$) difference was observed with respect to oxalates among the composite flours. Variations in the concentration of these antinutrients in plants vary with the specie, cultivar and processing methods. The values reported here for the various flour samples are within the acceptable limits of 10 mg/g and at this level they are beneficial to human health (Ojinnaka *et al.*, 2017).

Table 1. Pasting properties of aerial yam and cocoyam flour blends

Parameters	Flour blends						
(cP)	100AYF	90AYF:10CF	80AYF:20CF	70AYF:30CF	60AYF:40CF	50AYF:50 CF	100CF
PV	2822.00 $\pm$ 3.46	2754.00 $\pm$ 24.25	2502.33 $\pm$ 23.09	2523.67 $\pm$ 21.93	2357.67 $\pm$ 11.54	2378.00 $\pm$ 10.39	3085.33 $\pm$ 15.01
TV	2544.33 $\pm$ 5.77	2506.33 $\pm$ 20.21	2310.00 $\pm$ 67.55	2371.00 $\pm$ 20.78	2227.67 $\pm$ 15.94	2285.00 $\pm$ 12.12	2088.33 $\pm$ 20.21
BV	294.33 $\pm$ 19.63	247.67 $\pm$ 4.04	225.67 $\pm$ 13.28	152.67 $\pm$ 1.15	130.00 $\pm$ 4.58	93.00 $\pm$ 1.73	997.00 $\pm$ 5.20
FV	3998.66 $\pm$ 27.14	3948.33 $\pm$ 12.70	3545.66 $\pm$ 61.78	3430.67 $\pm$ 98.15	3321.33 $\pm$ 10.97	3231.67 $\pm$ 23.09	3014.00 $\pm$ 8.66
SV	1454.33 $\pm$ 21.36	1442.00 $\pm$ 32.91	1169.00 $\pm$ 51.96	1059.67 $\pm$ 77.36	1093.67 $\pm$ 5.13	933.33 $\pm$ 0.58	925.66 $\pm$ 11.55
P _{ti} (mins)	6.26 $\pm$ 0.11	6.42 $\pm$ 0.04	6.70 $\pm$ 0.03	6.78 $\pm$ 0.15	7.00 $\pm$ 0.00	6.68 $\pm$ 0.07	4.87 $\pm$ 0.07
P _{te} (°C)	86.17 $\pm$ 0.45	85.65 $\pm$ 0.05	85.62 $\pm$ 0.03	85.65 $\pm$ 0.05	85.68 $\pm$ 0.03	86.60 $\pm$ 1.16	85.37 $\pm$ 0.38

Values represent means and standard deviation of triplicate determinations. Mean values with different superscript in a row are significantly ($p \leq 0.05$) different from each other.

PV= peak viscosity, TV= trough viscosity BD= breakdown viscosity, FV= final viscosity SV= setback viscosity P_{ti}= pasting time, P_{te}= pasting temperature . AYF=Aerial yam flour,

CF = Cocoyam flour

Table 2. Some antinutritional factors in aerial yam and cocoyam flour blends

ANFs mg/100g	100AYF	90AYF:10CF	<u>flour blends</u> 80AYF:20CF	70AYF:30CF	60AYF:40CF	50AYF:50CF	100CF
Phytate	23.87 ^a ±0.9	23.81 ^a ±0.13	22.52 ^b ±0.81	20.40 ^c ±0.40	18.00 ^d ±0.82	14.01 ^e ±0.02	10.10 ^f ±0.37
Cyanide	13.26 ^a ±0.52	15.27 ^a ±0.51	17.27 ^a ±0.95	21.17 ^a ±0.42	22.00 ^a ±0.72	25.57 ^b ±0.63	29.96 ^a ±0.74
Tannin	18.44 ^a ±0.41	18.00 ^{ab} ±0.31	17.48 ^{abc} ±0.40	17.62 ^{abc} ±0.54	17.21 ^{bc} ±0.59	16.85 ^c ±0.71	15.06 ^d ±0.77
Saponin	36.21 ^a ±0.64	31.61 ^b ±1.07	32.69 ^b ±0.85	30.34 ^a ±0.54	29.63 ^{cd} ±0.55	28.45 ^d ±0.59	26.56 ^e ±0.58
Oxalate	8.00 ^a ±0.20	8.00 ^a ±0.10	8.30 ^a ±0.01	8.00 ^b ±0.01	8.07 ^b ±0.00	8.40 ^b ±0.01	9.03 ^a ±0.02

Values represent means and standard deviation of triplicate determinations. Mean values with different superscript in a row are significantly ($p \leq 0.05$) different from each other
ANFs = antinutritional factors, AYF=Aerial yam flour, CF = Cocoyam flour

CONCLUSION

Based on the evaluation of the pasting properties and antinutritional factor of the aerial yam and cocoyam flour composite blends in this study, it can be summarized that the inclusion of cocoyam in the blends resulted in lower breakdown viscosities hence paste stability in high temperatures. They may well suit for consumption as stiff porridge which is consumed by a larger populace. Although the antinutritional factors varied in the composite flours their values are low and within the acceptable limit hence may not have serious adverse effect on nutrient bioavailability and at this quantities, it could be more advantageous to the consumer. Further work should be carried out on these blends in the area of micronutrients determinations, starch digestibility, sensory evaluation and nutritional evaluation such that individuals with diet related disease and diet restrictions like the obese and diabetics could benefit.

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QUALITY ASSESSMENT OF PLANTAIN PEEL FOR FOOD FORMULATION.

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Abstract

Plantain (*Musa paradisiaca*) peel is considered a waste and hence only used as animal feed or for soap making. Some selected chemical properties of plantain peels were evaluated using standard methods. The results obtained showed that there was a significant difference in the proximate composition of unripe and ripe plantain peels. Unripe plantain peels had higher carbohydrate but lower protein content than those of the ripe plantains. Although starch yield from the ripe peels were low, plantain peels generally have the potential for use in food formulations.

Keywords: *plantain, peel, unripe, ripe, proximate, waste.*

Introduction

Plantain (*Musa paradisiaca*) belongs to the family of *Musaceae* with the genus *Musa* and has been a crop of extraordinary significance to human societies. It can be differentiated from banana by the number of fingers in the bunch, a characteristic used in naming the fruit in many parts of Southern part of Nigeria (Ighodaro, 2012). Over 2.11 million metric tons of plantains are produced in Nigeria annually, which contributes substantially to the nutrition of subtropical local population (Akinsanmied *et al.*, 2015). High consumption of plantain fruits in Nigeria in particular and by extension in West Africa, generates solid wastes in the form of peels, which are typically discarded and only a small fraction of them are fed to pigs. In countries like Somalia, it is considered for use as organic fertilizers to enrich soils and enhance better crop production and yield (Okarehet *et al.*, 2015). Plantain peels also called the plantain skin refers to the outer covering of plantain (*Musa paradisiaca*) fruit. Plantain peel which accounts for about 40 % of the total fruit weight (Gilver and Liliana, 2017). has been reported to have the potential as a promising raw material which could find useful industrial applications especially in the agro-based industries. The major wastes of plantain processing in Nigeria are their peels which are mostly regarded as wastes and often discarded indiscriminately in landfills, drainages and road sides, consequently, posing as threat to the environment (Autaand Kumurya, 2015). This study was aimed at evaluating some selected chemical properties of plantain peels to determine its suitability for use in food formulations.

Material and Methods

Unripe and Ripe plantains were harvested from a farm in Umuahia, Abia State, Nigeria. The peels were gently separated from the pulp using a sharp knife. The peels were then prepared for analysis as prescribed by Akinsanmiet *al.*, (2015). Both ripe and unripe plantain peels were collected and washed properly, to eliminate any contaminants. The peels were grouped as collected, cleaned, rinsed with distilled water, and manually sliced thinly (0.5-1.0mm thick). The sliced portions were immediately air-dried and pulverized and passed through a 100-mesh sieve, resulting in free-flowing powder. Proximate composition was determined using the method prescribed by Onwuka, (2018). Selected chemical properties were determined using method prescribed by Fontes *et al.*, (2017). Statistical analysis of the data was done using analysis of variance and the differences between means were considered significant at $p < 0.05$.

Results and Discussion

The results showed that there was a significant difference in the proximate composition of the unripe plantain peel and the ripe plantain peel as shown in Table 1. The moisture content of the ripe plantain peel (56.74%) was higher than that of the unripe peel (46.44%). This could be attributed to the moisture gained from the atmosphere during the process of ripening or as a result of the overall chemical and microbial processes/activities as the fruit ripened (Adamu *et al.*, 2017). Moisture content is a very important parameter in food composition as it determines the means of processing as well as the shelf-life and storage of the food (Akinsanmiet *al.*, 2015). The protein, ash and crude fibre contents of ripe plantain peels with values 6.67%, 2.04% and 5.25% respectively were higher than those recorded of the unripe plantain peel with values (4.78%, 1.46% and 3.61%) respectively. On the other hand, the fat and carbohydrate content of the unripe plantain peel with values 2.34% and 41.39% respectively were higher than those recorded for the ripe peel with values 1.90% and 27.41%. Starch yield and amylose content for the ripe plantain peels were low with the values 4.40% and 16.83%. However, the amylopectin content of each peel was high.

Table 1: Proximate composition and Chemical properties of plantain peels

Proximate composition (%)	Unripe plantain peel	Ripe plantain peel
Moisture	46.44* $\pm$ 0.22	56.74* $\pm$ 0.59
Dry matter	53.57* $\pm$ 0.22	43.27* $\pm$ 0.59
Fat	2.34* $\pm$ 0.14	1.90* $\pm$ 0.01
Protein	4.78* $\pm$ 0.04	6.67* $\pm$ 0.06
Ash	1.46* $\pm$ 0.09	2.04* $\pm$ 0.16
Crude fibre	3.61* $\pm$ 0.05	5.25* $\pm$ 0.04
Carbohydrate	41.39* $\pm$ 0.08	27.41* $\pm$ 0.82
Chemical properties		
Starch yield	11.89* $\pm$ 0.01	4.40 * $\pm$ 0.06
Amylose	32.03* $\pm$ 0.05	16.83* $\pm$ 0.33
Amylopectin	49.59 * $\pm$ 0.06	57.28* $\pm$ 0.04

Values are mean $\pm$ standard deviation of duplicate determinations. *Means are significantly ($p < 0.05$) different.

The proximate composition of ripe plantain peel was high when compared with those of yam, sweet potato, carrot, and irish potato peels as reported by Itelima *et al.*, (2014). The protein contents of both ripe and unripe plantain peels can contribute significantly to the daily human protein requirement (Shadrach *et al.*, 2020). Results from the properties evaluated, show that both peels can be processed properly and eaten as food. This implies that plantain peel can be used to prepare food such as *Amala* which is produced from yam peel flour. It can also be processed into flour to be used for baking.

Conclusion

Plantain peel waste should not only be used as animal feed but should be adopted for food formulations in the food industry. The utilization of plantain peel for food should be given more attention.

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SENSORY EVALUATION AND SHELF STABILITY OF SOME SELECTED ORGANIC PRESERVATIVES ON MANGO JUICE

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Abstract

A comparative study of some selected organic preservatives on the shelf-life of mango juice was carried out. Sensory analysis of the samples was carried out according to standard methods. Mango juice was produced and preserved using African black pepper, lime juice, ginger and orange peel and was studied for changes in the sensory attributes for 20 days. The sensory evaluation results showed that all the organoleptic properties such as taste, flavour, appearance, mouth-feel and overall acceptability of samples reduced with increase in the storage period. However, the lime preserved sample (LPS) was most acceptable and rated highest among others at the end of the storage period. Lime juice could therefore be said to be a better organic preservative among those studied.

Keywords: Organic, Preservatives, Shelf-life, Sensory, Mango

Introduction

Mango (*Mangifera indica*) is a tropical ever green fruit-bearing tree, commercially grown in many countries and popular both in the fresh and the processed forms in many parts of the world. It is well-known as king among the tropical fruits (Yadav *et al.*, 2017). It is one of the most popular and valued fruit because of its attractive colour, delicious taste and excellent nutritional properties (Abdalla *et al.*, 2020). Mango is the most economically important fruit in the *Anacardiaceae* family (Yadav *et al.*, 2017). Other important members of this family include cashew and pistachio. Mango is the most important fruit for inhabitants of the tropics after banana (Yadav *et al.*, 2017). Mango fruit production generally starts in January and ends in July/August. This production, hitherto almost exclusively for local consumption, reached its peak in March, April and May (Sakhaleet *et al.*, 2012). Mango contains all kinds of chemical elements which are helpful to the body but, it falls under the category of perishable fruits and cannot be stored for long time. Consequently, mangoes are consumed in ample amount as fresh fruits during their season (Mahadee and Shahidul, 2014).

Due to the comparatively short storage life of mango fruits, it is essential to prepare their products immediately. It is therefore, necessary to process mango fruits to make juices, drinks, jams, squashes, nectars, chutney, pickles, toffees and canned mango slices so that they

may be enjoyed during the off seasons. Processing of the fruit is aimed at shelf-life improvement. However, food product quality is not constant. Rather, it changes with storage time. Most times, there is always a limitation in its shelf-life due to deteriorative chemical reactions (Younis, 2011). Among all quality attributes, colour is often the first characteristic consumers use to evaluate the overall product quality.

Reports have shown that various research have been done to preserve fruit juice quality through the addition of different chemical preservatives such as sodium metabisulphite, potassium sorbate, and sodium benzoate which serve as antimicrobial agents inhibiting the growth of bacteria, molds and other microorganisms. Synthetic preservatives help to retain the overall acceptability of nutrients stability and reduce microbial load (Usage *et al.*, 2017). There is a gradual shift in demands of food products preserved with synthetic chemicals because of the adverse effect of long-time consumption of these inorganic preservatives on the health of consumers (Olaniran *et al.*, 2020). This study was therefore aimed to identify the most suitable organic preservative for mango from the four samples.

Materials and Methods

Raw materials; mango fruits, African black pepper, orange peels, lime and ginger were obtained from central market, Anyigba, Kogi State. Reagents and equipment for analysis were from food chemistry laboratory of Prince Abubakar Audu University, (PAAU), Anyigba, Kogi State.

The organic black pepper preservative extract was prepared according to the method described by (Orishagbemiet *al.*, 2020). Black pepper was washed, dried (60°C, 2hr) cooled and grinded into powder and then packaged into air-tight container. Lime juice was prepared as described by (Ameh *et al.*, 2015). The limes were washed, squeezed to get the juice. The fresh juices were dispensed in bottles for use. The ginger rhizomes were sorted and washed with tap water repeatedly. The outer covering was peeled off with a sterile knife and sliced into cutlets of about 2cm and dried for 10 days in a green house. An electric blender (Athena9, India) was used to pulverize the dried ginger into powder and stored in an air-tight container. Unripe matured orange fruits were washed with water and sorted to ensure that only the wholesome ones were used for the experiment. The peels were removed with a clean knife; the fresh peels were spread on trays and dried for 10 days in a green house. The dried peels were grinded into powder. The powder was stored in an air-tight container ready for use.

Mangoes fully ripped, free from rot and minimal mechanical injuries were harvested from Prince Abubakar Audu University (PAAU) campus, Anyigba. Uniform fruits with similar size and colour were selected and hand washed with tap water. Mango juice was produced in the laboratory as described by (Sakhale *et al.*, 2012). The pulp was extracted. A given quantity of the mango pulp was mixed with water in the ratio of 1:2 (weight/volume) and the mixture were stirred for 5 minutes using a stirrer. It was then filtered and the filtrate was weighed. The filtrate was pasteurized for 15 minutes at 65°C. The mixture was cooled to room temperature. The mango juice sample was divided into five parts of 30cl each. A 5% (w/w) of the organic preservatives were added to four of the mango juice. The organoleptic

attributes (appearance, taste, flavour, mouth-feel) of mango juice in storage were evaluated by twenty (20) semi-trained panellists who were familiar with mango juice, based on 9-points' *Hedonic* scale rating (Orishagbemiet *al.*, 2020). Analysis of variance (ANOVA) was used to analyse data obtained and differences in mean values were evaluated at $p \leq 0.05$, using Turkey's test.

Results and Discussion

It was observed from Table 1 that the sensory qualities of samples were negatively affected with storage time. Mango juice samples depreciated with storage time. MJS and LPS had highest appearance score and were significant difference ($p \leq 0.05$) from other samples. However, African black pepper preservative sample APS retained its colour up to the 4th day of storage and was significantly different ($p \leq 0.05$) from other samples. This could be due to the presence of pigment in APS. The taste scores of the MJS were significantly ($p \leq 0.05$) higher than the rest samples and rapidly decreased with period of storage. Sample LPS had a slight sour taste for the first 2 weeks and slightly decreased in the third week of the experiment. The retention of the original taste for longer period could be attributed to the sour taste of the organic acid present in the organic preservative which prevented taste loss. This observation is similar to that of (Orishagbemiet *al.*, 2018). Flavour scores were high for all samples. The flavour scores generally reduced in all the samples as storage progressed. Apparently, sample LPS had desirably acceptable mouth-feel at the end of week 3 under ambient storage conditions. Deteriorated mouth-feel is attributable to the synthesis of diverse bio molecules by the proliferating microorganisms. All samples were acceptable at day 0. APS was significantly higher in flavour and lower in taste, appearance, mouth-feel and overall acceptability. This trend was followed until day 16. The flavour of APS dropped drastically to the least among the samples. MJS decreased rapidly in all assessed organoleptic properties. MJS and APS were the least acceptable, followed by OPS, and GPS. LPS was most acceptable after 3 weeks of study.

Conclusion

The use of organic preservatives affected the shelf life as well as the sensory attributes of the mango juice. It is therefore concluded that lime juice is the preferred organic preservative amongst others in this study.

Table 1: Effect of organic preservatives on mango juice stored at ambient temperature

Parameter	Sample	0 th Day	4 th Day	8 th Day	12 th Day	16 th Day	20 th Day
Appearance	MJS	8.1 ^d	± 7.7 ^d ± 0.30	7.1 ^{bc} ± 0.31	7.0 ^c ± 0.33	6.2 ^c ± 0.25	5.8 ^c ± 0.23
		0.23					
	APS	7.4 ^a	± 7.2 ^a ± 0.33	6.6 ^a ± 0.40	6.3 ^a ± 0.42	5.4 ^a ± 0.45	4.6 ^a ± 0.45
		0.30					
	LPS	8.1 ^d	± 7.5 ^c ± 0.17	7.2 ^c ± 0.33	7.2 ^d ± 0.25	6.4 ^d ± 0.22	6.2 ^d ± 0.20
		0.18					

Taste	GPS	7.9 ^c 0.23	±	7.3 ^b ± 0.33	7.1 ^{bc} ± 0.40	6.9 ^c 0.31	±	6.0 ^b ± 0.26	5.3 ^b ± 0.21	
	OPS	7.6 ^b 0.16	±	7.3 ^b ± 0.21	7.0 ^b 0.30	6.6 ^b 0.37	±	6.1 ^{bc} ± 0.28	5.8 ^c ± 0.29	
	MJS	8.3 ^d 0.26	±	8.1 ^c ± 0.23	7.2 ^c 0.25	6.1 ^c 0.38	±	5.3 ^c ± 0.34	3.5 ^b 0.34	±
	APS	6.8 ^a 0.42	±	6.4 ^a ± 0.45	6.2 ^a 0.42	5.0 ^a 0.42	±	4.3 ^a ± 0.37	2.8 ^a 0.25	±
	LPS	7.8 ^c 0.44	±	7.6 ^b ± 0.27	6.9 ^b 0.31	6.3 ^c 0.37	±	5.7 ^d ± 0.30	4.2 ^c 0.25	±
Flavor	GPS	7.6 ^c 0.43	±	7.5 ^b ± 0.27	7.2 ^c 0.25	5.8 ^b 0.25	±	4.6 ^b ± 0.22	4.1 ^c ± 0.35	
	OPS	7.3 ^b 0.33	±	6.7 ^a ± 0.37	6.3 ^a 0.42	5.7 ^b 0.42	±	5.2 ^c ± 0.33	4.2 ^c ± 0.36	
	MJS	7.8 ^c 0.29	±	7.6 ^c ± 0.27	6.3 ^b 0.40	6.1 ^c 0.38	±	5.2 ^b ± 0.33	4.0 ^a 0.47	±
	APS	8.0 ^d 0.30	±	7.8 ^d ± 0.21	6.7 ^c 0.34	5.0 ^a 0.42	±	4.8 ^a ± 0.36	4.2 ^b 0.49	±
	LPS	7.6 ^b 0.31	±	7.5 ^c ± 0.34	6.7 ^c 0.30	6.3 ^c 0.37	±	5.6 ^c ± 0.27	4.6 ^c 0.34	±
Mouth- feel	GPS	7.9 ^{cd} ± 0.23		7.3 ^b ± 0.30	6.6 ^c 0.37	5.8 ^b 0.25	±	5.2 ^b ± 0.42	4.9 ^d ± 0.38	
	OPS	7.2 ^a 0.25	±	7.0 ^a ± 0.33	6.1 ^a ± 0.38	5.7 ^b 0.42	±	4.7 ^a ± 0.33	4.1 ^{ab} ±0.31	
	MJS	8.5 ^c 0.22	±	7.1 ^c ± 0.30	6.0 ^b 0.26	5.4 ^b 0.34	±	4.0 ^b ± 0.39	3.6 ^b 0.45	±
	APS	7.4 ^a 0.40	±	6.3 ^a ± 0.26	5.9 ^a 0.38	4.5 ^a 0.45	±	3.6 ^a ± 0.36	2.9 ^a 0.35	±
	LPS	8.1 ^b 0.23	±	7.2 ^c ± 0.33	6.2 ^d 0.33	5.8 ^c 0.29	±	4.5 ^d ± 0.31	4.3 ^d 0.34	±
Overall Accept.	GPS	8.0 ^b 0.30	±	6.6 ^b ± 0.37	6.1 ^c 0.28	5.8 ^c 0.39	±	4.2 ^c ± 0.36	3.8 ^b ± 0.36	
	OPS	7.5 ^a 0.40	±	6.5 ^b ± 0.34	6.1 ^c ± 0.41	5.4 ^b ± 0.30		4.1 ^b ± 0.28	4.0 ^c ± 0.39	
	MJS	8.0 ^e 0.26	±	7.4 ^d ± 0.31	7.2 ^c 0.29	6.5 ^b 0.40	±	6.3 ^b ± 0.50	4.3 ^a 0.62	±
	APS	6.9 ^a 0.53	±	5.8 ^a ± 0.59	5.3 ^a 0.67	4.8 ^a 0.59	±	4.7 ^a ± 0.58	4.2 ^a 0.53	±
	LPS	7.7 ^d 0.26	±	7.2 ^d ± 0.31	7.2 ^c 0.31	7.0 ^c 0.26	±	6.5 ^c ± 0.37	5.1 ^c 0.62	±
	GPS	7.5 ^c 0.27	±	6.9 ^c ± 0.35	5.9 ^b 0.46	6.8 ^{bc} ± 0.25		6.3 ^b ± 0.42	5.0 ^{bc} ±0.45	
	OPS	7.2 ^b 0.36	±	6.4 ^b ± 0.40	6.9 ^c ± 0.31	6.8 ^{bc} ±0.33		6.1 ^b ± 0.35	4.9 ^b ± 0.38	

Values are expressed as mean of 20 panellists $\pm$ standard deviation. Values with the same superscripts on the same column are not significantly different ($p > 0.05$).

MJS = Mango juice (100%)

APS = Mango juice (95%) + African Black Pepper (5%)

LPS = Mango juice (95%) + Lime Juice (5%)

GPS = Mango juice (95%) + Ginger Powder (5%)

OPS = Mango juice (95%) + Orange Peels Powder (5%)

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PRODUCTION OF ENRICHED “GARI” FROM BLENDS OF CASSAVA MASH AND PIGEON PEA FLOUR

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ABSTRACT

The production of gari from blends of cassava mash and pigeon pea flour, and evaluation of the proximate composition and cyanide content of the blends were carried out. Seven blends were produced from different proportions of cassava mash and pigeon pea flour in the ratios of 95:5, 90:10, 85:15, 80:20, 75:25, 70:30 and 100:0 (control). The proximate composition and cyanide content of the blends were determined using standard methods. Significant differences ($p < 0.05$) existed in the values of the proximate composition and cyanide content. The proximate composition indicated significant ($p < 0.05$) increase in protein (1.87 – 3.66 %), ash (1.01 – 1.66 %), fat (0.72 – 1.30 %), crude fibre (0.68 – 1.26 %), while significant ($p < 0.05$) decrease in carbohydrate (88.51 – 84.96 %) as the inclusion of pigeon pea flour into the gari increased. The cyanide content significantly ($p < 0.05$) decreased with increase in the addition of pigeon pea flour. This study has shown that enriched gari with improved nutritional quality and safety can be produced from gari-pigeon pea flour blends.

Keywords: Enriched gari, cassava mash, pigeon pea flour, blends, cyanide

Introduction

According to FAO (2017), Nigeria is the main producer, consumer and exporter of gari. Gari is a staple food for many people of various ages and socio-economic status in Nigeria and other sub-Saharan African countries. Gari accounts for over 70% of the entire cassava production in Nigeria. Cassava root used in producing gari is low in nutrients such as protein, vitamins and minerals (Olugbemiet *al.*, 2010), but rich in carbohydrate and is highly perishable, which necessitates its processing into stable products like gari. Gari is very palatable and has long shelf life. Pigeon pea has high protein content (Nwanekeziet *al.*, 2017), and has the potential to supply quality protein needed to improve the protein content of gari. Gari can be consumed in different forms such as stiff paste (eba) with soup, soaked in water with sugar, palm kernel, coconut, etc. However, the consumption of cassava and its products, and pigeon pea are limited by the content of antinutrients such as cyanide, phytate, saponin, alkaloids, among others. Processing methods such as soaking, fermentation, toasting, boiling, etc., can be used to reduce these antinutrients (Nwanekeziet *al.*, 2017a).

The prevalence of protein malnutrition in Nigeria necessitated the desire to supplement gari with pigeon pea flour. Pigeon pea is rich in nutrients and its inclusion into gari will increase the protein content of gari, thereby improving the protein intake of the people. Processing of these crops into gari will reduce postharvest losses in pigeon pea and cassava roots, and introduce new varieties of gari, thereby adding values to the crops. The objectives of this study were to produce enriched gari from cassava and pigeon pea,

and evaluate the proximate composition and cyanide content of the blends.

Materials and Methods

Raw Materials

Cassava roots and pigeon pea seeds were purchased from Ubani Main Market in Umuahia North Local Government Area, Abia State.

Production of Cassava Mash and Pigeon Pea Flour

Two kilograms of cassava roots were washed and manually peeled with a knife, washed again and grated in a locally fabricated mechanical grater to produce the mash. Two kilograms of pigeon pea seeds were sorted, cleaned, washed and soaked in water for about 12 h after which the seeds were manually dehulled by rubbing between the palms. The grains were dried in an oven at 60 °C for 7 h (Gallenkemp, 300 Plus, England), milled into flour using disc attrition mill (Asiko A11, Addis Nigeria) and sieved with 0.25 mm particle size mesh. The pigeon pea flour was then mixed with the cassava mash in a basin, packed into a hessian bag and left to ferment for two days. Then, the mash was dewatered in a hydraulic press and the cake sifted with a woven sieve made from raffia to remove fibrous materials.

Blending of Cassava Mash and Pigeon Pea Flour

Table 1 presents the blending of different proportions of cassava mash and pigeon pea flour for the production of pigeon pea gari, where 100% cassava mash served as control.

Table 1: Blending of Cassava Mash and Pigeon Pea Flour

Samples	Cassava mash %	Pigeon pea flour %	Total %
100:0	100	0	100
95:5	95	5	100
90:10	90	10	100
85:15	85	15	100
80:20	80	20	100
75:25	75	25	100
70:30	70	30	100

Production of Gari

The formulated blends of cassava mash and pigeon pea flour were made up of 7 samples including the control sample. The production of gari was done as described by Amponsah (2018) with slight modification. The frying pan was placed on fire and left to heat up for 5 minutes. Then, each of the blends of cassava mash-pigeon pea flour were added to the pan and toasted separately for about 15 - 20 minutes with regular stirring to arrest the formation of lumps and burning, and to guarantee uniform heating of the granules. After toasting, the gari samples were removed from the frying pan and spread over clean stainless steel tray to cool, and packed in polyethylene bags for further studies.

Proximate Composition Determination

Proximate compositions (moisture, protein, fat, fibre, ash) of the samples were determined in triplicates except for carbohydrate content which was determined by difference as described by AOAC (2005).

Cyanide Content Determination

Cyanide content was determined using the method of Bradbury *et al.* (1985).

Statistical Analysis

The laboratory data obtained were subjected to analysis of variance using the SPSS version 22, while treatment means were separated using Duncan's Multiple Range Test at 95% confidence level ($p < 0.05$).

Results and Discussion

Proximate Composition and Cyanide Content of Blends of Pigeon Pea Gari

Table 2 shows the proximate composition and cyanide content of blends of pigeon pea gari. The results showed that there was no significant difference ($p > 0.05$) in the moisture content of the blends. The moisture contents of the gari-pigeon pea blends recorded low values. The moisture content of a food product is used to estimate its storability and shelf life. This indicates that the blends will exhibit shelf stability since their moisture contents are lower than 12 – 12.13%, being the maximum moisture content recommended for shelf stable gari (Makanjuola *et al.*, 2012). There were significant differences ($p < 0.05$) between all the measured parameters of protein, ash, fat and crude fibre contents of the formulated blends which increased with increasing addition of pigeon pea flour while the carbohydrate content decreased. Protein is crucial to the regulation and maintenance of the body. The protein contents of the formulated blends were higher than that of the control sample. This could be attributed to the inclusion of pigeon pea flour in the blends since pigeon pea is rich in protein. This justifies the aim of this study to enrich the staple food of the people with protein so as to mitigate the incidence of protein malnutrition. The ash content of a food indicates its total mineral content. The rise in ash content of the formulated gari blends as the level of pigeon pea flour increased in the blends could be attributed to the high ash content of pigeon pea flour. Pigeon pea is a good depository of minerals (Nwanekezie *et al.*, 2017, Arukwe and Nwanekezi, 2022). This suggests that the formulated blends will help to improve the mineral intake of the gari consumers, thereby ameliorating the effects associated with micronutrient deficiencies in developing countries (Arukwe and Nwanekezi, 2022). Fat content of the blends were low. The low fat content will ensure longer shelf life of the blends because chances of rancidity will be drastically reduced. The increase in the crude fibre content of the pigeon pea gari obtained in this study could be attributed to the addition effect of pigeon pea flour inclusion on the gari, since pigeon pea is rich in fibre. This increase in crude fibre for the enriched gari samples is advantageous because dietary fibre has been reported to reduce the incidence of diabetes, colon cancer, heart disease, among others.

Table 2: Proximate Composition and Cyanide Content of Pigeon Pea Gari

Sample CM:PP	Moisture %	Protein %	Ash %	Fat %	Crude Fibre %	Carbohydrate %	Cyanide g/100g
100:0	7.21 ^a ±0.01	1.87 ^g ±0.0	1.01 ^g ±0.02	0.72 ^g ±0.01	0.68 ^g ±0.0	88.51 ^a ±0.01	0.005 ^a ±0.0
95:5	7.20 ^a ±0.02	2.40 ^f ±0.01	1.12 ^f ±0.0	0.80 ^f ±0.01	0.75 ^f ±0.01	87.73 ^b ±0.02	0.004 ^b ±0.0
90:10	7.22 ^a ±0.00	2.62 ^e ±0.02	1.19 ^e ±0.01	0.90 ^e ±0.02	0.84 ^e ±0.02	87.23 ^c ±0.00	0.004 ^b ±0.0
85:15	7.20 ^a ±0.01	2.90 ^d ±0.01	1.30 ^d ±0.0	1.10 ^d ±0.00	1.05 ^d ±0.00	86.45 ^d ±0.0	0.003 ^c ±0.0
80:20	7.21 ^a ±0.02	3.18 ^c ±0.0	1.40 ^c ±0.01	1.15 ^c ±0.0	1.13 ^c ±0.02	85.93 ^e ±0.01	0.002 ^d ±0.0
75:25	7.20 ^a ±0.0	3.40 ^b ±0.02	1.51 ^b ±0.0	1.22 ^b ±0.01	1.20 ^b ±0.0	85.47 ^f ±0.01	0.002 ^d ±0.0
70:30	7.22 ^a ±0.01	3.66 ^a ±0.01	1.60 ^a ±0.01	1.30 ^a ±0.02	1.26 ^a ±0.01	84.96 ^g ±0.02	0.001 ^e ±0.0

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Key: CM=Cassava mash, PP=Pigeon pea flour, 100:0=100% cassava gari, 95:5=95% cassava gari and 5% pigeon pea flour, 90:10=90% cassava gari and 10% pigeon pea flour, 85:15=85% cassava gari and 15% pigeon pea flour, 80:20=80% cassava gari and 20% pigeon pea flour, 75:25=75% cassava gari and 25% pigeon pea flour, and 70:30=70% cassava gari and 30% pigeon pea flour.

There were significant differences (p<0.05) in the carbohydrate and cyanide contents of the blends. The carbohydrate content of the pigeon pea gari blends reduced with increase in percent pigeon pea flour. This suggests that the consumption of pigeon pea gari will be good for diabetic patients that require low carbohydrate diets. The cyanide content of the blends also decreased with increased inclusion of pigeon pea flour to the blends. The reduction in the cyanide content values might have been due to fermentation, heat used for toasting and dilution effect of the pigeon pea flour. The values obtained for cyanide were lower than the recommended standard value of 20 mg/kg (NIS 181, 2004). The low values recorded suggest better nutritional quality and safety of the blends.

Conclusion

This study has revealed the possibility of producing enriched gari with cassava and pigeon pea flour. The inclusion of pigeon pea flour to the blend for gari production increased the protein, ash, and crude fibre contents and reduced the carbohydrate and cyanide contents, thereby producing gari of better quality and safety.

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STORAGE STABILITY OF HIGH QUALITY CASSAVA FLOURS PRODUCED FROM VARIETIES OF LOW POSTHARVEST PHYSIOLOGICALLY DETERIORATED CASSAVA (*MANIHOT ESCULENTA CRANTZ*)

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ABSTRACT

This study investigated the storage stability of some quality attributes of high quality cassava flours (HOCFs) produced from varieties of low postharvest physiologically deteriorated (PPD) cassava stored in three packaging materials [low density polyethylene (LDPE), Purdue improved crop storage (PICS) - HDPE bag and plastic container (PC)] for 24 weeks. Cassava roots were processed into HQCFs, analyzed for proximate properties and microbial load at 8 weeks interval. Completely randomized design with fifteen replications was used and data obtained were subjected to general linear model procedure of SPSS (version 25) for analysis of variance, $\alpha=0.05$ in all cases. Mean value from 0 to 24 weeks for moisture, protein, ash, fat, carbohydrate, dry matter and energy content was 7.60 ± 0.67 - 5.53 ± 0.75 %, 0.20 ± 0.07 - 0.17 ± 0.21 %, 0.46 ± 0.20 - 0.44 ± 0.30 %, 0.46 ± 0.20 - 0.32 ± 0.66 %, 91.28 ± 0.73 - 93.55 ± 0.07 %, 92.40 ± 0.87 - 94.45 ± 0.26 % and 1546.50 ± 1.32 - 1581.44 ± 0.04 KJ/kg. Mean for total viable bacterial and fungal counts ranged 0.00 to $1.36\times10^2\pm0.25$ cfu/g and $3.00\times10^2\pm0.67$ to $1.63\times10^2\pm0.43$ cfu/g. HQCFs from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, and IITA-TMS-IBA-011371 cassava were shelf stable and fit for human consumption for 24 weeks at ambient condition in PICS bag, LDPE bag and PC being the most suitable for good product quality.

Keywords: Cassava flour, storage period, quality attribute, microbial quality, shelf stability

1.0 Introduction

Cassava has become a significant food security and industrial crop, contributing as food, feed and industrial biomass in Africa, Asia and South America (Ayetigboet *al.* 2018). Notably, cassava production rose from 132,200,764 tons to exactly 157,271,697 tons in 2010 to 2016, respectively, which was about 18.9% (FAO, 2018). Also, the production share of cassava by

region: Africa (60.7%), Americas (9.9%), Asia (29.3%) and Oceania (0.1%) from 2017 to 2018 (FAO, 2020). The total production of cassava in Africa in 2018 was 169,673,737 and Nigeria share in this production was 50,485,047 (FAO, 2020).

Cassava (*ManihotesculentaCrantz*) characteristically has short postharvest life requires quick transportation to point of processing, especially when it is meant for the production of high quality cassava flour (HQCF). The reduced market potential of cassava due to high “postharvest physiological deterioration (PPD)” phenomenon made stakeholders in its value chain to loose enthusiasm (Rajuet *al.*, 2015; Alimiet *al.*, 2021). Therefore, the development (screening) of some low PPD cassava varieties targeted at extending the shelf life of cassava root from two days (48hrs) to 5 days (120hrs) and enhancement of nutritional value such as increased β -carotene (pro-vitamin A), starch, dry matter content, and reduced moisture) is a research development in the right direction in proffering solution to the challenge in cassava value chain (Alimiet *al.*, 2021). Hence, this study examined the effect of packaging materials and storage period on some quality attributes of HQCFs produced from varieties of cassava screened for delayed or low postharvest physiological deterioration (PPD).

2.0 Materials and Methods

2.1 Materials

Flours from five (5) varieties were used for the study. Four yellow fleshed varieties screened for low postharvest physiological deterioration are: IITA-TMS-IBA011368 (yellow), IITA-TMS-IBA070596 (yellow), IITA-TMS-IBA011412 (yellow), IITA-TMS-IBA011371 (yellow) and one variety of high postharvest physiological deterioration: TMEB419 (white) were provided by International Institute of Tropical Agriculture (IITA), Ibadan.

2.2 Production, packaging and storage of high quality cassava flour used in the study

Wholesome cassava used for this study were provided by International Institute of Tropical Agriculture (IITA) which was processed into HQCF. The wholesome cassava roots (28.86 kg) were subjected to unit operations such as peeling, washing in a clean water so as to remove dirt and extraneous material that could be adhered to the roots. The washed roots were then grated and pressed with screw jack press to remove water from the mash. The cake was reduced to very small particles (pulverizing) (12.22 kg) and subsequently dried with the aid of flash dryer at 120 °C. The flour that was dried using a flash dryer was reduced (milled) to flour using cyclone hammer mill to which a mesh size of 250 μ m was attached. The cooled flours (7.8 kg) were packaged in (200 g) separate using low density polyethylene (LDPE), plastic containers and Purdue Improved Crop Storage – HDPE (PICS) bags under aseptic conditions. The flours from the five different cassava varieties were packed and stored at ambient (27 $\pm$ 3°C) environmental conditions.

2.3 Determination of the proximate composition and microbial assay

The proximate parameters of the HQCFs were determined following the standard analytical procedures (AOAC). Carbohydrate content in percentage was estimated employing difference Equation (1) (Nwabueze and Anoruoh, 2011). An equation which was a factor was used in calculating the energy value expressed in KJ/kg (2) (Akuboret *al.*, 2003). The dry matter of the HQCF was estimated using Equation (3) (Etudaiyeet *al.*, 2009).

$$\text{Carbohydrate (\%)} = 100 - \text{percentage (protein + fat + moisture + ash)} \quad (1)$$

$$\text{Energy value Kcal/kg} = (\text{Protein} \times 4 + \text{fat} \times 9 + \text{carbohydrate content} \times 4) \quad (2)$$

$$\text{Dry matter (\%)} = (100 - \text{Moisture content}) \quad (3)$$

The flours prepared from the clones of low PPD cassava were evaluated for total bacteria and fungi counts. This was carried out using the pour-plate method following ICMSF (1988) procedure.

2.4 Statistical analysis

All experimental data obtained were subjected to the general linear model (GLM) procedure of SPSS (version 25) for the analysis of variance. In all cases, $\alpha=0.05$.

3.0 Results and Discussion

The range of mean value from 0 to 24 weeks for moisture, protein, ash, fat, carbohydrate, dry matter and energy content was 7.60 ± 0.67 - 5.53 ± 0.75 %, 0.20 ± 0.07 - 0.17 ± 0.21 %, 0.46 ± 0.20 - 0.44 ± 0.30 %, 0.46 ± 0.20 - 0.32 ± 0.66 %, 91.28 ± 0.73 - 93.55 ± 0.07 %, 92.40 ± 0.87 - 94.45 ± 0.26 % and 1546.50 ± 1.32 - 1581.44 ± 0.04 KJ/kg, respectively. The moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination (Kayodeet *al.*, 2014). Generally, before storage, the moisture content of the flours prepared from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, IITA-TMS-IBA-011412, IITA-TMS-IBA-011371 and TMEB419 were within the safe moisture level (12-14%) for flour products. Protein, ash and fat content increased during storage

Table 1: Mean and interactive effect of cassava variety, packaging materials and storage period on proximate properties of HQCFs from low PPD cassava

Variables	MC (%)	Prot. (%)	Ash (%)	Fat (%)	CHO (%)	DM (%)	Energy V. (KJ/kg)
Cassava Varieties							
IITA-TMS-IBA-011368	6.27±0.71 ^a	0.27±0.20 ^a	0.76±0.19 ^{bc}	0.32±0.87 ^b	92.38±1.38 ^a	93.73±0.71 ^a	1563.10±3.23 ^c
IITA-TMS-IBA-070593	6.28±0.66 ^a	0.26±0.20 ^a	0.52±0.30 ^a	0.46±1.66 ^d	92.48±1.94 ^a	93.72±0.66 ^a	1570.29±3.79 ^d
IITA-TMS-IBA-011412	7.32±1.27 ^d	0.27±0.14 ^a	0.79±0.20 ^c	0.27±2.61 ^a	91.36±1.35 ^a	92.65±1.21 ^a	1544.44±2.89 ^a
IITA-TMS-IBA-011371	6.77±0.75 ^c	0.30±0.21 ^b	0.57±0.32 ^a	0.55±1.02 ^c	91.81±1.51 ^b	93.22±0.75 ^b	1563.21±2.58 ^c
TMEB419	6.65±0.62 ^b	0.30±0.29 ^b	0.73±0.17 ^b	0.37±1.60 ^c	91.96±1.18 ^c	93.35±0.62 ^c	1557.95±2.52 ^b
Storage period (Weeks)							
0	7.60±0.67 ^d	0.20±0.07 ^b	0.46±0.20 ^a	0.46±0.20 ^b	91.28±0.73 ^b	92.40±0.87 ^a	1546.50±1.32 ^b
8	7.25±0.55 ^c	0.51±0.15 ^c	1.20±0.07 ^b	0.50±0.17 ^c	90.53±0.53 ^a	92.75±0.55 ^b	1543.55±2.72 ^a
16	6.86±0.53 ^b	0.18±0.31 ^a	0.44±0.15 ^a	0.33±1.96 ^a	92.19±2.53 ^a	93.14±0.53 ^a	1559.45±3.80 ^c
24	5.53±0.75 ^a	0.17±0.21 ^a	0.44±0.30 ^a	0.32±0.66 ^a	93.55±0.07 ^d	94.45±0.26 ^d	1581.44±0.04 ^d
Packaging materials							
PICS	6.58±0.83 ^b	0.29±0.22 ^b	0.69±0.15 ^a	0.38±1.61 ^a	92.06±2.22 ^{ab}	93.45±0.83 ^b	1560.93±3.99 ^a
LDPE	6.66±0.86 ^c	0.27±0.19 ^a	0.67±0.14 ^a	0.36±1.26 ^a	92.04±1.92 ^a	93.34±0.86 ^a	1559.39±2.02 ^a
Plastic container	6.44±0.94 ^a	0.30±0.23 ^c	0.71±0.14 ^a	0.42±1.02 ^b	92.12±2.64 ^b	93.54±0.91 ^c	1563.44±4.54 ^b
EFFECT							
Range	7.60 - 5.53	0.20 - 0.17	0.46 - 0.44	0.46 - 0.32	91.28 - 93.55	92.40 - 94.45	1546.50 - 1581.44
Means	6.66	0.28	0.67	0.39	91.99	93.33	1559.77
SD	0.91	0.17	0.38	0.17	0.98	1.00	1.49
SE	0.03	0.01	0.07	0.01	0.01	0.01	0.11
p Variety (V)	***	***	***	***	***	***	***
p Storage (S)	***	***	***	***	***	***	***
p P.mat. (PM)	***	***	NS	***	NS	***	***
p SxV	***	***	***	***	***	***	***
p SxP	***	NS	NS	NS	***	NS	NS
p VxP	***	NS	NS	NS	NS	NS	NS
p SxVxP	***	NS	NS	***	NS	NS	NS

*** indicate significant effect at $p \leq 0.001$; NS indicate not significant; PICS: Purdue improved crop storage; LDPE: Low density Polyethylene; MC: Moisture content; CHO: Carbohydrate; DM: Dry matter; Prot.: Protein; Energy V.: Energy value; P. mat.: Packaging material

Table 2: Mean and interactive effects of cassava variety, packaging materials and storage period on microbiological qualities of HQCFs from low PPD Cassava

Variables	Total viable bacteria count (cfu/g)	Total viable fungal count (cfu/g)
Cassava Varieties		
IITA-TMS-IBA-011368	1.39x10 ² ±0.57 ^a	1.99x10 ² ±0.58 ^b
IITA-TMS-IBA-070593	1.38x10 ² ±0.60 ^a	2.04x10 ² ±0.46 ^b
IITA-TMS-IBA-011412	1.70x10 ² ±0.70 ^c	2.61x10 ² ±0.48 ^c
IITA-TMS-IBA-011371	1.59x10 ² ±0.66 ^d	1.50x10 ² ±0.33 ^a
TMEB419	1.42x10 ² ±0.60 ^b	1.92x10 ² ±0.53 ^b
Storage period (Weeks)		
0	ND	3.00 x10 ² ±0.67 ^d
8	2.07x10 ² ±0.25 ^d	2.16 x10 ² ±0.44 ^c
16	1.55x10 ² ±0.30 ^c	1.92x10 ² ±0.40 ^b
24	1.36x10 ² ±0.25 ^b	1.63x10 ² ±0.43 ^a
Packaging materials		
PICS	1.67x10 ² ±0.36 ^b	1.94x10 ² ±0.46 ^b
LDPE	1.85x10 ² ±0.37 ^c	2.08x10 ² ±0.46 ^b
Plastic container	1.46x10 ² ±0.36 ^a	1.59x10 ² ±0.42 ^a

EFFECT		
Range	(0.00 - 1.36) $\times 10^2$	(3.00 - 1.63) $\times 10^2$
Means	1.50 $\times 10^2$	2.01 $\times 10^2$
SD	0.63	0.59
SE	0.02	0.05
p Varieties (V)	***	***
p Storage (S)	***	***
pP.mat. (PM)	***	***
p SxV	NS	NS
p SxP	NS	NS
p VxP	NS	NS
p SxVxP	NS	NS

*** indicate significant effect at $P \leq 0.001$; NS indicate not significant

PICS: Purdue improved crop storage; LDPE: Low density Polyethylene; P.mat: Packaging material; PM: Packaging materials

while carbohydrate, dry matter and energy value increased with increasing storage period. The mean values of total viable bacterial and total viable fungal count isolated and identified during the storage of low PPD cassava flour for 24 weeks when stored in different packaging materials are presented in Tables 2. No viable bacterium was detected in the flour samples at day zero (0) when the cassava flours were freshly produced and this could be attributed to the lethal effect of the drying temperature (120 °C) resident in the flash drier suppressing their emergence and subsequent growth. The highest total viable bacterial count (1.80 ± 0.14 cfu/g) after 24 weeks of storage was recorded in flour prepared from IITA-TMS-IBA-011371 packed in LDPE. The range of value for the total viable bacterial count in the cassava flours was (0.00 - 1.36) $\times 10^2$ cfu/g while the overall mean value was 1.50 $\times 10^2$ cfu/g (Table 2). The total viable fungal count (TVFC) of the flours varied significantly ($P < 0.05$) and ranged from 2.00 ± 0.00 - 3.50 ± 0.71 cfu/g, with flour prepared from IITA-TMS-IBA-011371 having the lowest count while the highest count was recorded in flours prepared from IITA-TMS-IBA-011368 and IITA-TMS-IBA-011412, respectively. The highest total viable fungal count (2.40 ± 0.14 cfu/g) after 24 weeks of storage was recorded in flour prepared from IITA-TMS-IBA-011412 (Table 2).

Conclusion

The high quality cassava flours (HQCFs) produced from IITA-TMS-IBA-011368, IITA-TMS-IBA-070593, IITA-TMS-IBA-011412, IITA-TMS-IBA-011371 cassava varieties screened for low PPD and TMEB419 (high PPD) were shelf stable (i.e. storage stable) and fit for human consumption for 24 weeks (six months) in PICS bag, LDPE bag and plastic container at ambient condition (27 ± 3 °C). Plastic container was the most suitable packaging materials recommended for packaging and storing low PPD cassava flours followed by PICS bag and lastly LDPE for good product quality.

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**PRODUCTION AND PHYSICOCHEMICAL PROPERTIES OF PALM OIL
SAMPLES COLLECTED FROM DIFFERENT MARKETS (ANKPA, DEKINA
AND OFU) IN KOGI EAST SENATORIAL DISTRICT.**

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Abstract

Palm oil is the most commonly used vegetable oil in Nigeria due to its numerous benefits (Agbaire 2012). Therefore, it is very important to investigate the quality of palm oil. In this study, oil samples were collected from different markets in Ankpa, Dekina, and Ofu in Kogi East senatorial district. Physicochemical properties of oil samples were evaluated using standard procedures. The result showed that the moisture content ranged from 0.22% to 0.59%, specific gravity ranged from 0.88 to 0.93, while saponification value (SV), iodine value, peroxide value, acid value and free fatty acid ranged from 178.68mg KOH/g to 230.01 mg KOH/g, 47.69 mg KOH/g to 53.25 mg KOH/g, 6.40 g/g oil to 9.90 g/g, 1.20 mg KOH/g to 1.96 mg KOH/g and 1.94% to 4.98% respectively. All samples showed > 35% SV suggesting the palm oil will be good in soap production. The result of the study has revealed that traditional methods of processing palm oil have significant effect on the quality of the oil products. However, other factors such as variety, soil, and climatic conditions may have contributed as well. The values of the physio-chemical properties of the various oil samples were within regulators standards and are therefore nutritionally and organoleptically acceptable.

Keywords: Physicochemical, Palm oil, Traditional, Varieties

Introduction

The term oil is used in generic sense to describe all substances that are greasy or oily fluid at room temperature (Agbaire, 2012). Generally, fats are considered as extracted triglycerides/lipids that are lipids under the same condition. Fats and oils belong to a larger group of naturally occurring substances called lipids. Because lipids serve as a convenient means of rapid heat transfer, they have found increasing use in commercial frying operations (Frank *et al.*, 2011).

Palm oil is an edible vegetable oil derived from the mesocarp of the fruit of the oil palm tree (*Elaeis guineensis*). It is an important part of human diet, and an essential raw material in some pharmaceutical and food manufacturing industries (Frank *et al.*, 2011. Ngando *et al.*, 2011). The distinctive colour of the oil is due to fat soluble carotenoids that are also responsible for

the high vitamin content (Ngando *et al*, 2011).

Like all oils, triglycerides are the major constituents of palm oil. More than 95% of palm oil consists of mixtures of triglycerides (glycerol molecules). Palm oil, (*Elaeis guineensis*) contains rich monounsaturated and polyunsaturated fats, providing a high level of bio available lipids than any other vegetable source (Bannie and Cho, 2000).

In Nigeria, many of the food industries use palm oil as their basic raw material because of its availability and cheapness (Ngando *et al*, 2011). It also serves as raw material in the pharmaceutical industries for the production of detergents, soap and cosmetics (Agbaire, 2012). The objective of this study is to evaluate the physicochemical properties of palm oil collected from three different markets in Kogi east senatorial district. (Ankpa, Dekina and Ofu).

MATERIALS AND METHODS

Study Area

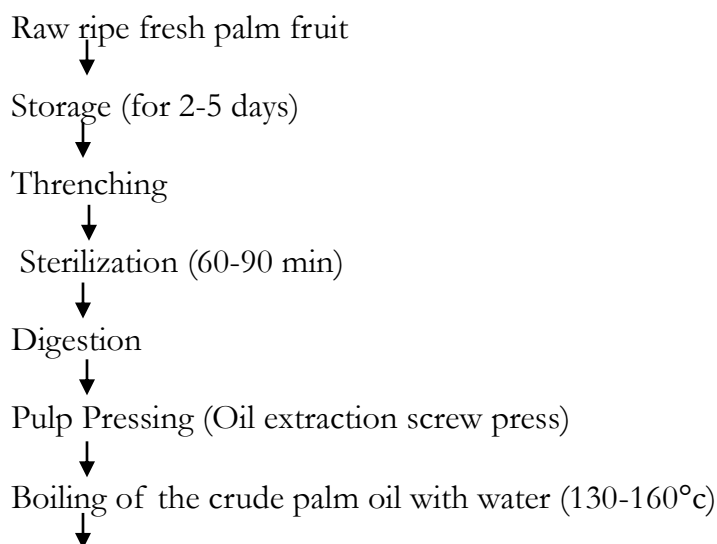
Five locations namely; Anyigba, Egume. Eiule. Ikanepko and KSU, in Kogi East Senatorial District were selected for this study.

Samples Collection

Five samples of palm oils were collected from different markets namely: Anyigba, Egume, Ejule, Ikanepko and KSU, in Kogi East Senatorial District. The samples were collected in glass bottles that were previously cleaned. The palm oil was then stored in black polythene bag to prevent exposure to light and transferred to the laboratory for analysis.

Production of palm oil at the units

Ripe palm fruits bunches were harvested, stored on the ground for 2-5 days at room temperature 37°C, and was threnched. The palm fruits was then sterilized at 60 to 90 min. by boiling at 130°C to 160°C followed by digestion of the fruit and then the oil was extracted by screw pressing. Thereafter, the extracted crude palm oil was boiled with water and then skimmed for proper clarification of the oil before drying by boiling and finally, packaging in bottles.



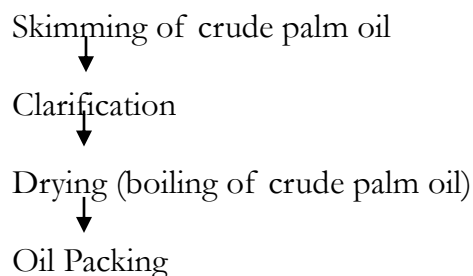


Fig 1. Flow chart for the production of Palmoil

Physicochemical Analysis of Palm oil

The physicochemical analysis which includes moisture content, peroxide value, iodine value, free fatty acid content, acid value, specific gravity, saponification value determination was carried out according to the method of AOAC (2005).

Statistical Analysis

The data obtained from the physicochemical analysis of the palm oil were subjected to statistical treatment using analysis of variance (ANOVA). $p < 0.05$

Results

Table 1 shows the Physicochemical Properties of Palm Oil from Ankpa, Dekina and Ofu, in Kogi East senatorial district. The table depicts that there is significant difference ($p < 0.05$) in all the physicochemical properties of the palm oil except for the saponification values.

1. Moisture Contents

The moisture contents of the palm oil are the water in oil which determine its degree of storage, the moisture contents of oil samples are significantly different ($p < 0.05$) and varied between 0.22% and 0.59%. Sample AAA (KSU oil) had the highest moisture (0.59%) while BBB (IKANEKPO Market Palm Oil) had the lowest (0.22%).

2. Specific Gravity

The specific gravity of the oil is the ratio of density at a specified temperature of the oil. The specific gravities of oil samples were significantly different ($p < 0.05$) and varied between 0.88% and 0.93%. Sample BBB had the highest specific gravity (0.93) while sample AAA had the lowest value of (0.88).

3. Acid Value

Acid value, being a measure of free fatty acid presence in oil, the suitability of the oil for any direct consumption or industrial application depends on its acid value (Norizzah, 2015). The acid values were significantly different ($p < 0.05$) and varied between 1.20 mg KOH/g to 1.96 mg KOH/g. These values were lower than 2.7 mg KOH/g obtained by Amira *et al.* (2014) for palm kernel oil.

4. Saponification Value

Saponification values (SV) of oils measure the number of mg of KOH necessary to saponify one gramme of the oil (Onwuka, 2014). The saponification value is in the range of 178.68 mg KOH/g to 230.01 mg KOH/g and are significantly different ($p < 0.05$).

5. Iodine Value

Iodine value of an oil sample shows the degree of saturation or unsaturation of oil

Sample	AAA	BBB	CCC	DDD	EEE
Moisture Content (%)	0.59±0.1 ^a	0.22±0.03 ^e	0.30± 0.00 ^d	0.45± 0.01 ^c	0.57± 0.01 ^a
Specific Gravity (mg KOH/g)	0.88± 0.00 ^c	0.93± 0.00 ^a	0.91± 0.00 ^b	0.90± 0.00 ^{bc}	0.89± 0.00 ^c
Acid Value (mg KOH/g)	1.96± 0.03 ^a	1.59± 0.01 ^b	1.20± 0.01 ^d	1.74± 0.00 ^a	1.49± 0.1 ^c
Saponification Value (mg/KOH/g)	178.68± 1.19 ^e	230.01± 0.00 ^a	222.16± 0.79 ^b	201.68± 0.79 ^c	190.74± 0.00 ^d
Iodine Value (gI ₂ /100g)	47.69± 0.04 ^d	53.25± 0.71 ^a	51.48± 0.49 ^{ab}	50.51± 0.00 ^b	48.71± 0.4 ^c
Peroxide Value (mg/g oil)	9.90± 0.14 ^a	5.14± 0.84 ^e	6.40± 0.00 ^d	7.48± 0.06 ^c	8.80± 0.00 ^b
Free Fatty Acid (%)	1.94± 0.02 ^e	4.98± 0.05 ^b	4.22± 0.02 ^c	3.45± 0.01 ^a	2.58± 0.01 ^d

component. Sample BBB had the highest IV (53.25 g/100g) while AAA had the lowest IV (47.69g/100g). The IV was higher than 8.5 to 15.86 g/100g reported by Amira *et al.* (2014).

6. Peroxide Value

Peroxide value (PV) is the most common indicator of lipid oxidation. The unrefined oils are characterized by greater PV, compared to refined oil. The PV of the oils ranged from 5.14 to 9.90 respectively and are significantly different ($p < 0.05$).

Free Fatty Acid

From the results of this study, the percentage of free fatty acid ranged from 1.94 to 4.98 respectively and are significantly different ($p < 0.05$). The free fatty acids content of all the oil samples were low when compared with Udensi and Iroegbu (2007) for palm oils evaluated.

Table 1: Physicochemical Properties of Palm Oil from Ankpa, Dekina, and Ofu in Kogi East Senatorial district

a,b,c,d, e..... Means with different superscript on the same row differ significantly ($p < 0.05$)

AAA = KSU Palm Oil

BBB = IKANEKPO Market Palm Oil

CCC = EJULE Market Palm Oil

DDD = EGUME Market Palm Oil

EEE = ANYIGBA market Palm Oil

CONCLUSION

This study has revealed that traditional methods of processing palm oil have significant effect on the physicochemical properties of the oil products. However, other factors such as variety, soil, and climatic conditions may have contributed as well. The values of the physio-

chemical properties of the various oil samples were within regulators standards and are therefore nutritionally acceptable.

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VALORIZATION OF ONION WASTE FOR THE DEVELOPMENT OF NUTRIENT-DENSE COOKIES

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Abstract

The study aimed to develop nutrient rich cookies incorporated with onion peel powder at different level (0%, 5%, 10% 15% and 20%). Nutritional and phytochemical analysis were determined using standard protocols for the onion peel powder (OPP), control cookies (CC) and 10% OPP incorporated cookies (OPPC10) were also analyzed. According to the sensory results, OPPC10 sample was found to have received highest sensory scores compared to the other samples. Furthermore, the cookies formulated with 10% OPP showed highest fiber content of 7.30%, carbohydrate content of 63% and protein content of 5% compared to the control sample as these levels are significantly higher in OPP. Phytochemical analysis showed that the total phenolic content of OPCC10 was 30 mg GAE/g while the flavonoid level was 43.70 mg QE/g which was considerable higher than CC. The present investigation showed that nutrient dense cookies can be developed by addition of 10% OPP without much compromising on the quality attributes.

Keywords: Onion peel powder, Cookies, Dietary fibre, Phytochemicals, Total phenolic content

Introduction

Onion (*Allium cepa* L.) which is a common vegetable belongs to the family *Amaryllidaceae*. Onions are biannual or perennial depending on the cultivar and are produced for food across the globe (FAO, 2012). The onion bulbs vary in shape and colour (red, white and yellow) (Fritsch, 2003). It is widely cultivated in India particularly in Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Bihar and Andhra Pradesh (Horticultural Statistics, 2018). Onions have diverse applications in food as pickles, powder, flakes, paste, onion powder, dehydrated flakes. Onion production has been drastically increased for the past two decades nevertheless, over 500,000 tons of onion waste is generated and is discarded in the European Union every year (Benitez *et al.*, 2011).

Onion waste generated during industrial processing includes dry skins, outer fleshy scales, stalks, roots, unused onion, and damaged bulbs. This waste disposal creates environment concerns owing to the fact that the waste is prone to microbial contamination that limits their food application (Michalak-Majewska *et al.*, 2020). Hence, there is a need for suitable technologies for the valorization of onion waste into a value-added food product. The onion waste was reported to contain several valuable nutrients and functional components for promoting health and hence considered as functional nutrient in food industries (Benitez *et al.*, 2011).

Several studies were conducted on the nutritional and biochemical characterization of edible onion bulbs while the studies on onion peel are scarce and completely neglected. The red skin and external layers contain substantial source of fiber and phenolic compounds such as quercetin and their flavonoids (Benitez *et al.*, 2011). Hence, onion skin can be utilized as a source of dietary fiber-rich ingredient in various food systems. In recent times onion peel or its extract was used as a functional ingredient in various food products such as gluten-free bread (Bedrnicek *et al.*, 2020), noodles (Sayed *et al.*, 2014), pasta (Michalak-Majewska *et al.*, 2020) to improve the shelf life and enhance the health benefits.

The present study was conducted for valorization of onion waste for the development of nutrient-dense cookies because the waste generated by onion processing industries creates environment concerns due to the fact that they are prone to microbial contamination which pollutes the environment. Hence, valorization of onion peel powder (0%, 5%, 10%, 15% and 20%) in development of cookies would provide value-addition to the onion waste and reduces environmental pollution.

Materials and methods

The red onion peels were collected from Thiruvannamiyur Onion Market, Chennai, Tamil Nadu, India. Refined wheat flour, butter, icing sugar and other raw materials were purchased from Shri Krishna Super Market, Kelambakkam, Tamil Nadu, India. All chemicals were of analytical grade and purchased from Sigma Aldrich, Steinheim, Germany.

Preparation of onion peel powder

The red onion peels were sorted out from moldy peels by manual separation. The sorted peels were washed twice using distilled water to remove dust particles and any foreign particles on the peels. The cleaned peels were spread over a tray and dried in Tray Dryer (TECHNICO, Chennai, India) at 50°C for 6 h then the peels were cooled down to room temperature and then powdered using an electric blender and then passed through 0.5 mm mesh screen. The obtained red onion peel powder (OPP) was packed in a sterilized container.

Preparation of OPP incorporated cookies (OPPC)

Cookies were prepared by taking one hundred and seventy-five grams (175g) of butter along with 100g of icing sugar and beaten using an electric beater until it becomes soft and fluffy. Further, 160g of refined wheat flour and red onion peel powder (5%, 10%, 15%, and 20%) were added to the mixture and kneaded. The dough is shaped, baked at 150°C for 15 min and then cooled to room temperature.

OPPC formulation:

Control cookies (CC) = 100% wheat flour + 0% (OPP)

OPPC5 = 95% wheat flour + 5 % (OPP)

OPPC10 = 90% wheat flour + 10 % (OPP)

OPPC15 = 85% wheat flour + 15% (OPP)

OPPC20 = 80% wheat flour + 20% (OPP)

Sensory properties of OPPC

Sensory evaluation was conducted for the control and onion peel powder incorporated cookies by 10 panellists. The panel members consisted of academic staff and students from

the Department of Food Technology, Hindustan Institute of Technology and Science, Padur, Chennai, India. The sensory test was conducted in a laboratory under normal (daylight) illumination and ambient temperature. Panellists evaluated the sensory properties of the CC and OPPC samples based using 9-points hedonic scale.

Nutritional composition of OPP and OPPC

Moisture, ash, carbohydrates, fat, protein, dietary fibre, total sugar, and energy were determined using AOAC (2002) protocol. Determination of aflatoxins in the samples was done according to the method described by AOAC (1995). The total phenolic and total flavonoids contents of the samples were analysed using modified UV spectrophotometric techniques as described by Nasriet *al.* (2011).

Statistical analysis

Data were analysed using SPSS Version 21.0 for Windows (IBM Corporation, New York, USA). Variability within the means was separated by Tukey–Kramer HSD and significances were accepted at a 5% confidence level ($p \leq 0.05$).

Results and discussion

The sensory evaluation report for the control cookies (CC) and cookies developed with different levels of red onion peel powder (OPPC5, OPPC10, OPPC15, OPPC20) were presented in the Figure 1. Results showed that addition of OPP led to significant improvement in all sensory attributes including body and texture, appearance, sweetness, saltiness, flavour and over all acceptability relative to CC sample. The results indicated that the OPPC10 sample prepared with 10% OPP recorded the highest score for all sensory parameters compared to its counter parts. It was observed from the experiment that the cookies prepared with 10% OPP and others exhibited higher flavour and taste scores compared with CC sample which may be due to typical onion flavour and volatile compounds in onion peel powder.

A decline in the overall acceptability scores were noticed when OPP was incorporated at a level beyond 10%. Similar results were reported for noodles prepared with onion skin powder by Sayed*et al.* (2014). These results demonstrated the feasibility in valorization of onion waste to highly acceptable cookies.

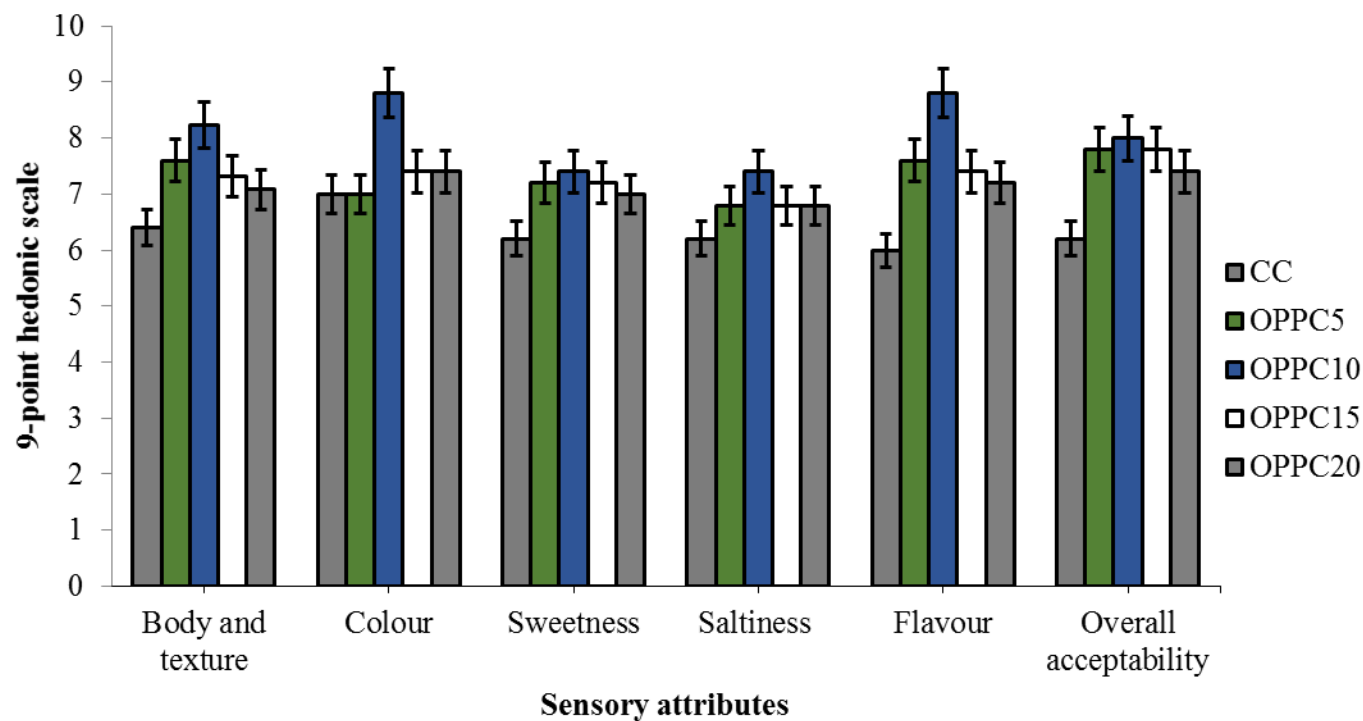


Figure 1.Sensory score analysis of control cookies (CC) and onion peel incorporated cookies (OPPC5, OPPC10, OPPC15& OPPC20)

According to the results of sensory analysis, cookies prepared with 10% red onion peel powder (OPPC10) was found to be highly accepted by the sensory panel members. Hence, the sample OPPC10 was used for further analysis. Table 1 presents the nutritional and phytochemical compositions of onion peel powder (OPP), control cookies prepared with 0% OPP and cookies prepared with 10% OPP (OPPC10). The data showed that red OPP comprises of substantial levels of ash (6%), carbohydrates (77%), and dietary fibre (78%) content. According to Michalak-Majewska*et al.* (2020) the ash, carbohydrates, and total dietary fibre contents of onion skin powder was observed to be 5%, 19%, and 62% respectively. The results also showed that there is no significant change in moisture and fat contents with the addition of 10% OPP in cookies. Ash content significantly increased ($p<0.05$) in OPPC10 compared with control. Both carbohydrate and fibre contents were improved in the OPPC10 due to the incorporation of OPP owing to the high dietary fibre in OPP. Similar results were reported for OPP fortified noodles by Sayed*et al.* (2014).

Table 1: Nutritional and phytochemical compositions of OPP, CC and OPPC10

Nutrients (%)	OPP	CC	OPPC10
Moisture	12.64±0.55 ^a	2.82±0.23 ^b	3.30±0.63 ^b
Ash	6.37±0.43 ^a	1.63±0.09 ^c	2.53±0.53 ^b
Fat	0.38±0.15 ^b	2.56±0.64 ^a	2.99±0.77 ^a
Protein	4.16±0.44 ^b	4.80±0.23 ^b	5.59±0.54 ^a
Carbohydrates	77.21±1.31 ^a	58.38±1.64 ^c	63.44±1.12 ^b
Energy (Kcal/100g)	322.72±10.47 ^c	467.26±10.01 ^b	502.33±11.78 ^a
Dietary fibre	78.92±3.30 ^a	2.77±0.22 ^c	7.30±0.62 ^b
Aflatoxin (µg/kg)	ND	ND	ND
Total phenolic content (TPC) (mg GAE/g)	30.58±1.97 ^a	0.18±0.01 ^c	3.37±0.94 ^b
Total flavonoids content (TFC) (mg QE/g)	43.70±3.33 ^a	0.07±0.03 ^c	4.78±0.75 ^b

Mean values followed by different letters (a, b & c) within the row are significantly different (p<0.05). OPP - Onion peel powder, CC - Control cookies, OPPC10 - Cookies prepared with 10% OPP, ND - Not detected.

On the other hand, Benítez *et al.* (2011) reported a dietary fibre content of 75% in brown onion skin powder. In general, the dietary fibre fractions of onion peel comprise of mostly cellulose, hemicellulose and pectin. The data revealed that OPP, CC and OPPC10 contain negligible amounts of aflatoxins. Furthermore, the results of phytochemical analysis showed that the TPC (total phenolic content) of OPP was 30 mg GAE/g while its TFC (total flavonoids content) was 43.70 mg QE/g which was considerable higher than the value reported by Michalak-Majewska *et al.* (2020) (41 mg QE/g) and Sayed *et al.* (2014) (18.75 mg QE/g). Furthermore, the increased concentrations of TPC and TFC in OPPC10 sample were attributed to the higher phytochemical levels of OPP.

Conclusion

The cookies formulated with 10% onion peel powder (OPPC10) have acquired highest sensory scores compared to the other samples. Further, these cookies showed superior nutritional value i.e., highest fiber content (7.30%), carbohydrate content (63%) and protein content (5%) compared to the control sample. Phytochemical analysis showed that the total phenolic content and flavonoid level of OPCC10 was considerable higher than CC.

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EFFECT OF PROCESSING METHODS ON THE MICRONUTRIENT CONTENTS OF *HEINSIA CRINATA* LEAF AND ITS PRODUCTS

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Abstract

Fresh leaves of *Heinsia crinata* were sorted, shared into five portions and given four treatments. Oven drying, blanching and drying, fermentation, and blanching and fermentation of the leaf. The mineral and vitamin content of the raw and processed leaf were subsequently determined, using standard methods. The results showed that the levels of micronutrients detected were generally high and ranged as follows: Na (0.24 – 1.07 mg/100g), Ca (11.69 – 63.00 mg/100g) and Fe (4.75 – 31.26 mg/100g). The vitamins contents ranged as follows– vit A (81.30 – 3111.22 IU), vit B₂ (0.1 – 6.13 mg/100g), vit E (0.12 – 53.31 mg/100g), and vitamin C (2.70 – 31.94 mg/100g). However, the various processing method used led to significant ($p < 0.05$) decrease of micronutrients in the extracts, while it caused a significant ($p < 0.05$) increase in the oven-dried sample.

Keyword: *Heinsia crinata*, Atama, Micronutrient, Vegetable, Processing methods.

Introduction

Vegetables occupy a special place among the food crops as they provide an adequate number of vitamins and minerals for humans. They have a high content of water and abundant of cellulose. The cellulose is in a form which although not digested, serves a vital purpose in the intestine as roughages, thus promoting the removal of waste products. Vegetables are known to contribute about 90 % of vitamins (45 % of vitamin A, 27 % of vitamin B, 17 % of thiamin, and 15 % of Niacin), in conjunction with fruits and nuts in the United States diet (Aletor and Adeogun 1995). Vegetable supply 16 % of Mg, 19 % of Fe, and 9 % of the per capita availability of protein in the United States diet, and their protein are of high quality relative to their content of essential amino acids. Other important nutrients supplied by vegetables include folic acid, riboflavin, Zinc, Calcium, potassium, and phosphorus (Gockowski *et al.* 2003).

In Nigeria, unlike the western world where green leafy vegetables are often consumed in their unprocessed forms, green leafy vegetables are usually subjected to various post-harvest treatments, such as drying, blanching, and fermentation (Oboh, 2005), to improve the taste and modify some of the acids present in the vegetables. These processing techniques had been reported to alter the nutrients of some commonly consumed plant foods in Nigeria (Oboh, 2005).

Heinsia crinata (Atama) is a green vegetable that belongs to a family called Rubiaceae. A large and mostly tropical family, they are largely found in temperate regions. The leaves are collected, washed in excess water, and then sliced. The sliced leaves are used to prepare soup.

Some studies on the phytochemical screening of medicinal plants identified alkaloids as one of the most active ingredients of West African plants that have an antimicrobial property (Hussein and Deeric, 1991). *Heinsia crinata* has high levels of alkaloids and cardiac glycosides that are mainly associated with antimicrobial activity among the phytochemical components of the medicinal plants (Otung, 1998). The present study is on the effect of processing methods on the micronutrient contents of *Heinsia crinata* leaf and Its products.

MATERIALS AND METHODS

Freshly plucked leaves of *Heinsia crinata* were bought from Akwa Ibom, Cross River State, Nigeria. The leaves were identified to be that of *Heinsia crinata* by a Plant Taxonomist in the Department of Zoology, University of Nigeria, Nsukka. The leaves were destalked, sorted thoroughly washed under running tap water, and allowed to drained for 1 hour at room temperature ($28 \pm 2^\circ\text{C}$). Drained leaves were sliced, divided into five portions.

Processing Steps is as follows: Sample 1

Steam blanching, oven drying, milling of the dried leaves, and packaging. Two hundred grams (200 g) of the leaves was steam blanched at 100°C for 8 min. After blanching, the sample was drained, dried at 50°C for 24 h, milled, and packaged in a moisture-proof nylon bag.

Sample 2

Oven drying, milling of the dried leaves, and packaging. The second portion (200 g) of the leaves was oven dried at 50°C for 24 h, milled to obtain dried leaf powder.

Sample 3

Steam blanching, wet milling, filtration, fermentation, pasteurization, and packaging. The third portion weighing 200 g was steam blanched at 100°C for 10 min. After blanching, the sample was wet milled using 250 mL of water (2:2.5) in a Kenwood Blender- BL300/BL350 and filtered using a sterilized muslin cloth. After filtration, the sample was fermented at room temperature ($28 \pm 2^\circ\text{C}$) for a period of 5 days and the extract was pasteurized at 70°C for 30 mins.

Sample 4

Fermentation, wet milling, filtration, pasteurization, and packaging. The fourth portion weighing 250 g was fermented at room temperature ($28 \pm 2^\circ\text{C}$) for 5 days. Thereafter, the sample was wet milled using 250 mL of water (2:2.5) in a Kenwood Blender-BL300/BL350 series and filtered to separate the juice using a sterilized muslin cloth. The extract was bottled and pasteurized at 70°C for 30 min.

Sample 5

Raw leaves (This sample was used as control.)

Vitamin A, B₂, E, C and Mineral analysis was determined by AOAC (2010) method. Data collected were subjected to one-way analysis of variance (ANOVA) using SPSS package version 17.0. Means were separated using Duncan's New Multiple Range Test (Duncan, 1975). A difference was considered to be significant at $p < 0.05$.

Results and discussion

The mineral contents of the raw and dried leaf powder are presented in Tables 1. Data on mineral analysis indicated that drying, blanching and pasteurization caused significant ($p <$

0.05) reduction in the sodium (Na), calcium (Ca) and Iron (Fe) contents of the extracts. The results of the mineral analysis suggest that consumption of large quantities of the vegetable with other dietary sources of minerals is needed to meet the Recommended Daily Intake (RDI per day) of 2400 mg for sodium, 1000 mg for calcium, and 18 mg for iron. The low level of sodium in all the treated samples may have a deleterious effect on humans since sodium intake of less than 2 g/day increases calcium loss in urine. On the other hand, however, this level of sodium may be beneficial for use in sodium restricted diets (0.24 - 1.07 mg/100g), since high intakes can contribute to hypertension in some people (Wardlaw and Kessel, 2002). The results indicated that calcium contents of dried leaf powder samples (raw and blanched) had mean values ranging from 18.78 - 63.00 mg/100g, while that of pasteurized extracts had mean values of 11.69 - 12.29 mg/100g. These, including calcium rich vegetables in daily diets ensures the 20 - 25 % of the daily requirement for calcium. The cells need calcium; and more than 99 % of calcium in the body is used as structural components of bones and teeth. This represents about 40 % of all the mineral present in the body (Wardlaw and Kessel 2002). Iron is an essential trace element for hemoglobin formation and in the oxidation of carbohydrates, protein and fats (Adeyeye and Ofokiti, 1999). Iron content of leaf and its products compared favorably with the recommended daily intake of iron values ranging from 4.75 -31.26 mg/100g. Iron deficiencies and its associated anaemia is a major public health concern in the developing world. It has been reported that more than 60 % of children in Africa are affected. The high iron content of these vegetables, therefore suggest that they could go a long way towards alleviating this problem.

The vitamin contents of atama leaf and its products are presented in Table 2. The vitamin C values, of powdered leaves were not statistically the same. The values are 20.18 mg/100g in oven dried powder and 18.34 mg/100g in blanched / oven dried leaf powder. The lower level of vitamin C in the oven and blanched/ oven dried samples in relation to the raw leaf may be attributed to the fact that drying system used (oven drying) involved heat, moisture and / or light which might have caused its extensive damage by oxidation (Oshodi, 1992). Achinewhu (1983), reported 32 - 68 % loss of vitamin C during handling and processing of some tropical vegetables. High percentage losses of vitamin C content of these dried vegetables could also be due to enzymatic oxidation during preparation and oven drying. The vitamin C values of the leaf extracts ranged from 2.70 - 4.86 mg/100g. This decrease in vitamin C content agrees with that of Oboh (2005) who studied green leafy vegetables and reported vitamin C losses of 45 - 82.4 % during blanching and pasteurization process. The lower vitamin C contents of these leaf extracts in relation to raw leaves sample may also be attributed to dilution effect and loss during blanching and pasteurization. The recommended dietary allowance value for vitamin C is 60 mg. The Vitamin B₂ contents in blanched extracts and blanched fermented extracts were at the threshold of traces, when analyzed. According to Ihekoronye and Ngoddy (1985) nutrient losses that occur during blanching are caused by oxidation of water-soluble nutrients and thermal destruction.

Table 1: Effect of Processing Methods on Mineral Contents (mg/100g) of 'Atama' leaf and Its Products

Treatment	Sample	Sodium	Calcium	Iron
Raw leaf	Raw form	1.07±0.00 ^a	56.14±0.22 ^b	31.21±0.04 ^a
Oven dried leaf	Powdered form	1.06±0.01 ^a	63.00±0.03 ^a	31.26±0.01 ^a
Blanched & oven dried leaf	Powdered form	0.78±0.01 ^b	18.78±2.09 ^c	14.15±0.01 ^b
Blanched leaf extract	Liquid Form	0.24±0.01 ^d	11.69±0.03 ^c	4.75±0.07 ^d
Fermented leaf extract	Liquid Form	0.27±0.01 ^c	12.29±0.02 ^c	5.25±0.02 ^c
Blanched & fermented leaf extract	Liquid Form	0.26±0.01 ^c	12.29±0.01 ^c	5.24±0.01 ^c

Values are mean ± SD (n=2). Values within the same column with different superscript are significantly p< 0.05 different. KEY: SD = Standard Deviation, n = number

Table 2: Effect of Processing Methods on Vitamin C of 'Atama' Leaf and Its Products

Treatment	Sample	Vitamin A IU	Vitamin B ₂ (mg/100g)	Vitamin E (mg/100g)	Vitamin C (mg/100g)
Raw leaf	Raw form	3111.22±1.67 ^a	6.12±0.00 ^{ab}	53.31±0.02 ^a	31.94±0.04 ^a
Oven dried leaf	Powdered form	3107.10±1.56 ^b	6.13±0.00 ^a	53.21±0.03 ^b	20.18±0.03 ^b
Blanched & dried leaf	Powdered form	3102.01±1.43 ^c	6.11±0.00 ^b	53.16±0.01 ^c	18.34±0.03 ^c
Blanched leaf extract	Liquid Form	81.30±0.14 ^d	Trace	6.43±0.01 ^d	4.86±0.04 ^d
Fermented leaf	Liquid Form	83.20±0.00 ^d	0.1±0.00 ^b	0.13±0.00 ^e	2.71±0.01 ^e
Blanched & fermented leaf	Liquid Form	83.03±0.42 ^d	Trace	0.12±0.00 ^e	2.70±0.14 ^e

Values are mean ± SD (n=2). Values within the same column with different superscript are significantly < 0.05 different. KEY: SD = Standard Deviation, n = number

On drying the vitamin B₂ contents of raw dried atama increased significantly (p<0.05) to 6.13 mg/100g in relation to the raw leaf sample value of 6.12 mg/100g. Hahn and Payne (1997) stated that RDA per day values for the vitamins are 1.2 - 1.7 mg. This means that the raw sample may represent a good source of vitamin B₂ and hence be used to supplement B₂ deficient diet. The little or no value of vitamin B₂ content of the extract may have resulted from the dilution effect. The vitamin E values of the blanched fermented leaf extract (0.12 mg/100g) was the lowest while raw leaf (53.31 mg/100g) had the highest vitamin E content

among the samples. Significant decrease ($p < 0.05$) existed between the leaf extracts and dried leaf powdered samples. The decrease was not surprising since it had been reported that vitamin E is unstable to heat in the presence of air (Ottawa, 1993) and also as a result of dilution effect. Generally, most of the products contain significant quantity of vitamin E which is also very important in protecting the red blood cell membranes. (Wardlaw and Kissel, 2002). From the RDA per day value of vitamin E, one could deduce that the vegetable is rich in vitamin E. The results of vitamin A values of the samples ranged from 81.30 - 3111.22 IU. The decrease in the concentration of the vitamin A in dried leaf powder sample could be due to the activity of lipoxygenase enzymes which degrades carotenoids. The vitamin A contents of some of the products are within the recommended daily intake (RDI) of 3000 - 10,000 IU.

Conclusion

The leaf of *Heinsia crinata* has very high micronutrient potentials, however, the processing methods used (oven drying, blanching, fermentation, blanching/fermentation) led to significant ($p < 0.05$) decrease in micronutrients in the leaf extracts, while it caused a significant ($p < 0.05$) increase in the oven-dried leaf sample.

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SENSORY ATTRIBUTES OF MANUALLY AND MACHINE SLICED *OKAZI* (*Gnetum africanum*) LEAF OF DIFFERENT SLICE THICKNESS IN SOUP PREPARATION

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Abstracts

“Okazi” (*Gnetum Africanium*) leaf is a popular wild, indigenous green leafy vegetable used extensively in south eastern parts of Nigeria due to its palatability and taste. The edible leaves are usually cut into strips for preparation of various dishes ranging from stew to soups. “Okazi” has a characteristic thick papery-like leaf which is usually hard to cut due to its fibrous nature. “Okazi” leaf is one of the most significant and yet energy demanding post-harvest operation in vegetable processing which requires the use of machine. The study evaluated the sensory attributes of “Okazi” soup using hand and machine slices with different thickness of “Okazi” leaf. Descriptive research design and sensory evaluation were used. The study population comprised of 20 panelists. The results were analyzed using 9-point hedonic scale. The findings revealed that sample A and B with slice thickness and length of 0.3cm; 3.1cm; and 0.2cm; 3.0cm respectively had the highest acceptability in terms of appearance, aroma, texture and general acceptability. The result obtained showed that there were no significant ($p \geq 0.05$) differences in hand and machine slices of “Okazi” leaf with different slice thickness and length used in the soup preparation.

Keywords: “Okazi”, Hand slices, Machine slices Sensory Qualities, Acceptability

Introduction

Vegetables generally are edible parts of plants or food crops harvested and eaten fresh or as part of main dish and contain relatively high moisture when freshly harvested (Ihekoronye and Ngoddy, 1985). Vegetables are also agricultural products which are important sources of protective foods that are highly beneficial for the maintenance of good health and prevention of diseases (Shade et al., 2004). Although some vegetables can be raised comparatively at lower management costs and on poor marginal soil, they have remained underutilized due to lack of awareness of their nutritional values in favor of exotic vegetables (Odhav et al., 2007). However, a food processor will regard vegetables as plant material eaten with the main course of meal whether they contain seed or not. Vegetables maybe regarded as wild and could be trees, herbs, shrubs, climbers or erect plant that cut across plant kingdom. The edible portion may be shoot “e.g”, beet, carrot, sweet potatoes, a tuber storage stem such as taro, a bud, bulb or petiole. According to Ihekoronye and Ngoddy (1985), vegetables can be classified as leafy vegetables “e.g”, cabbage, fluted pumpkin, lettuce, spinach, bitter leaf, “Okazi” leaf, among others. Fruit vegetables “e.g”, cucumber, pepper, tomatoes, eggplant, okra, immature green legumes such as green beans, green peas, cereals such as sweet corn, modified bud vegetables “e.g”, onion, garlic. Flower vegetable cauliflower. Roots vegetables “e.g”, sweet potatoes, cassava etc. Tuber vegetable “e.g”, yam and potatoes and stem vegetables “e.g”, asparagus, etc.

Vegetables play an important role in the human diets, as they support the normal functioning

of the different body system. They provide our cells with vitamins such as B complex vitamin, vitamin C, and vitamin A, minerals such as calcium, iron, etc., fibers, essential oils and phytonutrients (Ray and Bhunia, 2007). Vegetable contains a low amount of fat and calories (Banerjee et al., 2012). Vegetables may be used as minor or major ingredients in food such as sauces, stew, soup, salads to serve the following functions: to enhance the flavor of food. Examples, onions, garlic, pepper among others. To garnish prepared dishes to enhance eye appeal. Examples are carrots green peas, green beans, among others.

“Okazi” (*Gnetum africanum*) is a leafy vegetable that belongs to the family *Gnetaceae* and occurs naturally in humid forest zone from Nigeria to Central African Republic and to Angola (Schipper and Bisong, 2000). The plant grows as a wild ever-green climbing plant in the rain forest of Nigeria where it is searched for and highly priced in the regional markets. It is an ever green dioecious forest perennial liana that grows up to 10 m long but sometimes longer and branched (Orwa et al., 2009). “Okazi” has wild and domesticated varieties. The wild variety is termed wild species while the recently domestically cultivated ones in the South Eastern Nigerian homes serve as exotic plants are termed the domestic species (Ali et al., 2011). The edible leaves are usually cut into small strips that are used by different countries for different cuisines and recipes ranging from stew and soups such as *edikang*, *afang*, *achara*, “Okazi” and egusi soups among others (Okerulu et al., 2015). “Okazi” leaf is an excellent source of aspartic acid, dietary fibre, protein, vitamins, sodium, magnesium, calcium, iron, zinc, manganese, potassium, copper, glutamic acid, leucine and essential amino acids that are required by the body. The relatively high protein content of “Okazi” suggests why this plant contains a high number of essential acids that can act as an alternative energy source especially when the carbohydrate metabolism is damaged due to glucogenesis (Okerulu et al., 2015). “Okazi” grows well in shaded areas and could be used as complimentary crop on tree farms. Specifically, it has been suggested that the vine could be used as a complimentary crop for rubber and oil trees. However, the necessity for shaded, but not excessively moist conditions may make it difficult for poor farmers to grow “Okazi” if they lack access to sustainable lands. However, since “Okazi” grow via rhizomes, it is not labour – intensive, therefore, allowing farmers to focus on physical capitals elsewhere. Sustainable cultivation practices such as harvesting the leaves regularly rather than uprooting the whole vine allows for a more viable supplementary income throughout the year. The FAO has found that the vine is easier to reproduce by cutting the seedlings rather than growing from seeds. Cutting the seedlings is one of the practical alternatives in harvesting the vine as opposed to destroying the entire crop by uprooting it (Schipper and Bisong, 2000). To harvest the leaves, the vine is often just yanked down off the tree, leaving the choicest top parts of the plant still entwined around high tree branches, and killing the plant at the same time. It’s not a very efficient way of harvesting the plant, especially combined with the treks that have to be made into the forest in search of it (Ali et al., 2011). There is no real tradition of cultivating the “Okazi” vine yet. Development agencies are working at dispelling the popular belief that it can’t be cultivated. Through cultivation, the agencies believe, could be more profitable as it would allow the vines to be trained so that the youngest, choicest leaves

would be within easy reach, and the leaves could be harvested without killing the plant “Okazi” produces a root tuber that may be used as a source of ‘famine food’ and it is similar to that of yam. The seed of the vine may also be eaten cooked as reported by Schippers and Bisong (2000). Economically, “Okazi” can be used as a means to maintain a supplementary income for rural farmers in Nigeria. Healthy leaves with thick-wax – like texture are preferred in the market and will receive the highest value. “Okazi” remains untaxed in local markets. Since the leaves may be consumed as a vegetable and the root tuber as famine food, it may also increase overall food security of rural household. Currently, slicing of “Okazi” leaf is done mostly by women manually using knives. This poses danger to individual for injuries are usually inflicted while slicing the vegetables. However, different machines utilize different slicing techniques such as reciprocating and rotary slicing method. They also have different blade designs, varying power consumption and different material selection which has overall effect on machine performances. Therefore, “Okazi” slicing needs to be mechanized to reduce energy and time spent in manual slicing and equally used in soup preparations just like the manually slices of “Okazi” which is the reason for this research.

Materials and methods

“Okazi” (*Gnetum africanum*) from different locations were procured from 808 *Imoke* Street, University of Nigeria, Nsukka and *Uzoakoli* in Abia State. The leaves were sorted to remove dried and discolored ones, cut into stripes manually using knife, tray and slicing board and mechanically using a fabricated manually operated “Okazi” slicing machine. The hand and machine slices of “Okazi” leaves were sorted according to their slice thickness and length and were coded as samples A (machine slices of the leaf from No 808 *Imoke* Street, UNN), sample B (hand slices of “Okazi” leaf from No 808 *Imoke* Street, UNN), sample C (machine slices of “Okazi” leaf from *Uzoakoli* farm in Abia State) and sample D (hand slices of “Okazi” leaf from *Uzoakoli* farm in Abia State). Two experienced okazi slicer from Abia state and Nsukka, Enugu state, handled the manual slicing of the “Okazi” using sharp knife, tray and chopping board. The difference between knife slices and machine slices of “Okazi” leaf was that knife slices were thinly sliced with less thickness compared with the machine slices of the leaf. The “Okazi” samples were used for the soup formulation. A well-structured questionnaire was used to assess the level of acceptability and consumption of the soups. The data were statistically analyzed using Analysis of variance (ANOVA) at ($p < 0.05$) level.

Soup formulation

The ingredient used in the preparation of “Okazi” soup includes: six hundred and twenty seven grams (627 g) of beef, two hundred and ninety four grams (294 g) of stockfish, eighty grams (80 g) machine and hand sliced “Okazi” leaf, three hundred and twenty seven grams (327 g) of dried fish, forty five (45 g) of crayfish, one hundred and forty one grams (141 g) of palm oil, forty grams (40 g) of salt, three hundred and fifteen (315 g) of egusi, eighty eight (88 g) of osu, seventeen (17 g) of seasoning cubes, thirty one (31 g) of ofor (thickener), forty two (42 g) of chili pepper and two thousand (2000) milliliters of water. The

meat was seasoned with stockfish, pepper, bouillon cubes (knor), salt and steamed using gas cooker at 80 °C for 20 minutes. The already washed dried fish was added together half way through steaming to avoid over cooking of the fish. The egusi seeds were washed, sundried and ground together with the osu. Fifteen (15 g) chili of pepper and was ground using kitchen blender(Panasonic, 1 speed MX 1021) until fairly smooth, the egusi was added to the ground pepper and pounded using mortar and pestle, one cooking spoon of warm water from the meat pot was added and pounded continuously until the egusi blended with signs of oiliness. The pounded egusi was stirred and broken into lumps. Water was added to the meat pot and boiled and crayfish, seasoning, chili pepper and palm oil were added and boiled for 10 minutes, continuously stirring until the oil changed from red to yellow. Ofor was sprinkled into the soup and stirred quickly to mix. Finally, “Okazi” leaves were added and allowed to cook for 3 minutes and the soup was ready. The same procedure was used to prepare other sliced “Okazi” leaf samples

Results and Discussion

Table 1: Sensory scores of soups prepared with different thicknesses of machine and manually sliced *Gnetum Africanium* “Okazi” leaf.

Samples	Colour	Appearance	Mouthfeel	Taste	Aftertaste	Flavour	Overall acceptability
A	8.35 ^b ±0.49	8.30 ^a ±0.57	8.45 ^a ±0.51	8.40 ^a ±0.50	8.45 ^a ±0.51	8.50 ^a ±0.51	8.30 ^a ±0.57
B	8.45 ^b ±0.51	8.55 ^a ±0.51	8.35 ^a ±0.49	8.40 ^a ±0.50	8.40 ^a ±0.50	8.55 ^a ±0.51	8.40 ^a ±0.47
C	8.00 ^c ±0.00	6.10 ^b ±1.65	7.65 ^b ±0.49	7.75 ^b ±0.71	7.70 ^b ±0.73	8.45 ^a ±0.51	7.90 ^b ±0.64
D	8.95 ^a ±0.22	6.35 ^b ±0.88	8.20 ^a ±0.89	8.05 ^{ab} ±0.68	7.80 ^b ±0.61	7.80 ^b ±0.52	7.75 ^b ±0.44

Values are mean ±standard deviation of 20 panelists. Values bearing different superscript within the same column are significantly $P \leq 0.05$ different.

Key: Sample A = Machine sliced *Gnetum africanium* leaves (“Okazi”) with slice thickness of 0.3 cm and slice length of 3.1 cm, Sample B = manually sliced *Gnetum africanium* with slice thickness of 0.2 cm and slice length of 3 cm, Sample C= Machine sliced *Gnetum africanium* leaves (“Okazi”) with slice thickness of 0.6 cm and slice length of 3.9 cm, Sample D = Knife sliced *Gnetum africanium* with slice thickness of 0.5 cm and slice length of 3.9 cm.

The colour for sensory scores of machines sliced *Gnetum africanium* leaf ranged from 8.00 in sample C to 8.95 in sample D. Sample A and Sample B were not significantly ($p \geq 0.05$) different from each other but samples C and Sample D were significantly($p < 0.05$) different from sample A and B. This maybe because of the slice thickness and length. The sizes were quite big. However, sample C is statistically different from sample D. This is because the fabricated machine was not automated but required arrangement of the leaves manually for the slicing operation which yielded uniformed slices of the leaf.

. The appearance, mouthful, taste, after taste, flavor and overall acceptability ranged from 6.35 to 8.30, 7.65 to 8.45, 7.75 to 8.40, 7.70 to 8.45, 7.80 to 8.50 and 7.75 to 8.40 respectively. Sample A and B were most preferred based on appearance, flavors, taste, aftertaste, appearance, mouthfeel, and overall acceptability compared with samples C and D which had effect on the mouthfeel, flavor and colour of the soups. Therefore, slice thickness and length had affect on the sensory profile of the soups

Conclusion

“Okazi” soup prepared using different slice thickness and length showed significant ($p < 0.05$) differences between the samples, as slice length and thickness have effect on the sensory scores of “Okazi” soup

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PHYTOCHEMICAL AND ANTIOXIDANT CHARACTERISTICS OF HERBAL TEA FROM SOURSOP, LEMONGRASS AND GINGER BLENDS

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Abstract

This study evaluated the phytochemical and antioxidant characteristics of herbal tea developed from soursop and lemongrass leaves composited with ginger rhizomes. Fresh leaves of soursop and lemongrass and rhizomes of ginger were cleaned and ultimately processed into herbal tea. The results showed saponin ranged between 1.26 mg/100g and 1.75 mg/100g, alkaloids (5.61 – 7.31 mg/100g), oxalate (1.12 – 1.23 mg/100g), tannin (4.01 – 5.37 mg/100g), flavonoids (28.29 – 33.28 mg RE/100g), steroids (12.39 – 14.22 mg/100g), and glucosides (6.10 – 7.90 mg/100g). The antioxidants results showed a total phenolic content of 1102.40 to 11422.50 mg GAE/100g, DPPH (3164.40 – 4022.90 µmolTEAC/100g), ferric reducing power (9.22 – 13.83 mmol Fe²⁺ /100g), and metal chelating (46.05 – 52.85%). The study showed that herbal tea from soursop and lemongrass leaves composited with ginger rhizomes is rich in phytochemicals and antioxidants. The formulated herbal tea could find domestic and industrial applications.

Keywords: Soursop, Lemongrass, Antioxidants, Phytochemicals, Herbal tea

Introduction

There has been a noticeable increase in the popularity and use of herbal teas in recent years. This corresponds to the current global rise in popularity and use of herbal treatments. Herbal teas are thus part of a rapidly developing sector of wellness beverages. Herbal teas are infusions or decoctions of mono- or poly-herbal recipes produced from herbal materials and are frequently used for their acknowledged health advantages as opposed to the aroma, flavour, and caffeine stimulant boost of tea (*Camellia sinensis*) brew (Zhang *et al.*, 2021). Herbal materials may include one or more botanical elements such as leaves, fruits, stems, roots, barks, and so on. Herbal teas are frequently caffeine-free. Depending on their indication or folk medicinal claims, they are frequently utilized for their therapeutic and/or nutritional effects (Zhang *et al.*, 2021). In Nigeria, many herbs with well-known nutritional and therapeutic properties are produced as infusions and decoctions for traditional home-usage. Soursop, lemongrass, and ginger are examples of such herbs. These herbs are well-known in Nigeria and are used as domestic seasonings in a variety of traditional cuisines and beverages. Herbal teas made from decoctions and infusions are frequently consumed for their nutritional and therapeutic effects.

Lemongrass (*Cymbopogon citratus*) has long been prized for its fragrant characteristics. Lemongrass infusion creates a fragrant drink with a distinct lemon flavour (Kamaruddin *et al.*, 2021). Lemongrass contains a variety of essential oils, compounds, minerals, and vitamins that are recognized to have antioxidant and disease-fighting capabilities. Lemongrass, both fresh and dried, is high in minerals such as potassium, zinc, calcium, iron, manganese, copper, and magnesium. Soursop (*Annona muricata* Linn) leaf is a herb that has anti-diabetic, anti-inflammatory, insecticide, antimalarial, anticancer, antibacterial, and antioxidant properties. Soursop leaf has several benefits due to its high concentration of phytochemical components (Hasmila *et al.*, 2019). Ginger (*Zingiber officinale* Roscoe) is a *Zingiberaceae* plant. It has been used therapeutically for millennia in African, Asian, Indian, European, and Middle Eastern cultures to treat problems such as arthritis, stomach trouble, asthma, diabetes, and menstrual abnormalities, to name a few. There is solid evidence that ginger can aid with nausea and vomiting following pregnancy, surgery, cancer treatment, or motion sickness, as well as inflammation and pain (Singletary, 2010). The objective of this study was to evaluate the phytochemical and antioxidant characteristics of herbal tea from a composite of soursop, lemongrass, and ginger.

Materials and Methods

Sources and preparation of raw material

Freshly harvested leaves of lemongrass and soursop, and rhizomes of ginger were obtained from accredited farms in Unwana, Ebonyi State, Nigeria. The leaves were sorted, de-stalked, and cleaned in distilled water (1:90, w/v) to remove dirt and other extraneous materials. The leaves were allowed to drain through a plastic sieve for 30 min and then manually diced into 6 mm. Thereafter, the diced leaves were steamed and dried at 50 °C for 4 h using hot air oven (SM9053, Uniscope, England). The ginger rhizomes were peeled, washed using distilled water, drained, diced, steamed, and oven-dried at 50 °C for 6 h. The dried leaves and rhizomes were milled using an attrition mill and sieved using a mesh of aperture 212 µm. The milled samples obtained from soursop, lemongrass and ginger were then formulated into herbal tea at different blend ratios (40S:20L:40G; 50S:25L:25G and 20S:40L:40G) (Table 1). The formulated mixtures were packaged into a tea bag (Hebei Macrokun, China) and sealed using an electric impulse sealer (ME-200H, China).

Determination of phytochemical and antioxidants characteristics of herbal tea

Tannin, saponin, oxalate, alkaloids and glycoside were determined as described by Raji *et al.* (2019). Total flavonoid and total phenolic were carried out as illustrated by Naheed *et al.* (2017). The DPPH and FRAP were conducted as elucidated by Naheed *et al.* (2017).

Statistical analysis

A completely randomized experimentation technique was utilized to avoid systematic errors. Evaluation of significant difference among means at a 5% significant level by the Duncan test was performed using the SPSS version 17 (SPSS Inc., Chicago, III, USA).

Results and Discussion

Phytochemical characteristics of the herbal tea are presented in Table 1. The saponin ranged between 1.26 mg/100g and 1.75 mg/100g, alkaloids (5.61 – 7.31 mg/100g), oxalate (1.12 –

1.23 mg/100g), tannin (4.01 – 5.37 mg/100g), flavonoids (28.29 – 33.28 mg RE/100g), steroids (12.39 – 14.22 mg/100g), and glucosides (6.10 – 7.90 mg/100g). The differences observed in the values could be attributed to the level of substitution of each sample in the blends. The highest values of saponin, oxalate, tannin, flavonoids, and steroids were recorded for the sample formulated with 20% soursoy+40% lemongrass+40% ginger; which could be attributed to higher levels of lemongrass and ginger in the blend. Whereas, the highest values for alkaloids and glucosides were recorded for the sample of 50% soursoy+25% lemongrass+25% ginger; and this could be attributed to increased substitution of soursoy in the blend. Flavonoids possessed biological attributes such as anti-inflammatory, anti-hyperglycemic, and anti-tumor activities as well as antioxidants (Zhang *et al.*, 2015). Alkaloids have the potential to lower blood glucose, anti-hypertensive, anti-cancer, and antioxidant activities (Zhang *et al.*, 2015). Saponins are capable of arresting the free radicals and inducing antioxidant enzymes. Saponins are known to have hypo-cholesterolaemic, immune-stimulant, hypoglycemic effect, and anti-carcinogenic attributes. Tannins, which belong to polyphenolic compounds, possess health benefits associated with a reduction in chronic diseases. Steroids are complex lipophilic substances that manage cellular, tissue, and organ activities throughout the life cycle (Raji *et al.*, 2019).

Table 1Phytochemical characteristics of tea from soursoy, ginger and lemongrass blends

Parameter	40%S+20%L+40%G	50%S+25%L+25%G	20%S+40%L+40%G
Saponin (mg/100g)	1.68±0.01 ^b	1.26±0.02 ^c	1.75±0.01 ^a
Alkaloids (mg/100g)	6.23±0.02 ^b	7.31±0.02 ^a	5.61±0.02 ^c
Oxalate (mg/100g)	1.12±0.02 ^c	1.16±0.01 ^b	1.23±0.01 ^a
Tannin (mg/100g)	4.01±0.01 ^c	5.06±0.06 ^b	5.37±0.01 ^a
Flavonoids (mg RE/100g)	28.29±0.03 ^c	32.04±0.05 ^b	33.28±0.03 ^a
Steroids (mg/100g)	12.39±0.04 ^c	13.93±0.04 ^b	14.22±0.03 ^a
Glucosides (mg/100g)	6.71±0.07 ^b	7.90±0.01 ^a	6.10±0.01 ^c

S – soursoy; L – lemongrass; G – ginger

Values are means ± standard deviation (n=5). Values with the same superscript on the same row are not significantly different (p>0.05).

Antioxidants characteristics

The antioxidant attributes of the formulated herbal tea are presented in Table 2. The results showed a total phenolic of 1102.40 to 11422.50 mg GAE /100g, DPPH (3164.40 – 4022.90 µmolTEAC/100g), ferric reducing power (9.22 – 13.83 mmol Fe²⁺ /100g), and metal chelating (46.05 – 52.85%). The highest total phenolic, DPPH, ferric reducing power, and metal chelating were recorded for the herbal tea formulated with 20%S+40%L+40%G. The higher antioxidant activity observed in sample 20%S+40%L+40%G could be due to high percentage of ginger and lemongrass in the blend. Atalay and Erge (2017) reported the total phenolic of white tea as 8361 mg/100g and that of green tea as 10516 mg/100g. Meanwhile, Al-Obaidi and Sahib (2015) value 3300 mg/100g, 2300 mg/100g, 1900 mg/100g, and 1700 mg/100g for white tea, green tea, black tea, and tea wastes, respectively.

The DPPH scavenging is typically employed to investigate the free radical scavenging ability of a food commodity. Phenolic compounds are chemically described as substances with an aromatic ring connected to one or more hydroxyl groups (Durazzo *et al.*, 2019). The amount and position of hydroxyl groups influence their ability to scavenge free radicals and chelate metal cations, potentially lowering the risk of chronic disease. Phenolic compounds' antioxidant and anti-inflammatory characteristics have been linked to a lower risk of cancer, cardiovascular disease, type 2 diabetes, obesity, and neurological illness (Durazzo *et al.*, 2019).

Table 2 Antioxidants characteristics of tea from soursop, ginger and lemongrass blends

Parameter	40%S+20%L+40%G	50%S+25%L+25%G	20%S+40%L+40%G
Total Phenolics (mg GAE /100g)	1102.4±1.87 ^c	1350.70±2.08 ^b	1422.50±2.92 ^a
DPPH (μmolTEAC/100g)	3164.40±2.10 ^c	3258.70±0.61 ^b	4022.90±1.72 ^a
Feric Reducing Power (mmol Fe ²⁺ /100g)	9.22±0.01 ^c	9.96±0.02 ^b	13.83±0.08 ^a
Metal Chelating (%)	46.05±0.04 ^c	47.63±0.02 ^b	52.85±0.45 ^a

S – soursop; L – lemongrass; G – ginger

Values are means ± standard deviation (n=5). Values with the same superscript on the same row are not significantly different (p>0.05).

Conclusion

The study showed that herbal tea from soursop and lemongrass leaves composited with ginger rhizomes is rich in phytochemicals and antioxidants. The formulated herbal tea could find domestic and industrial applications.

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PHYSICOCHEMICAL AND SENSORY CHARACTERISTICS OF HERBAL TEA FROM SOURSOP, LEMONGRASS AND GINGER BLENDS

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Abstract

This study investigated the feasibility of formulating herbal tea from soursop and lemongrass leaves composited with ginger rhizomes. Fresh leaves of soursop and lemongrass and rhizomes of ginger were cleaned and ultimately processed into herbal tea. The tea samples were evaluated for physicochemical and sensory characteristics using standard procedures. The results showed packed bulk density of 0.335 to 372 g/ml, porosity (29 - 37%), pH (5.73 - 5.91), L* (77.63 – 82.72), a* (1.36 – 2.45), b* (15.10 – 20.24), and total dissolved solids (4.73 and 6.03 mg/g). The sensory results showed colour rating of (6.17 – 7.07), aroma (4.33 – 6.23), taste (2.83 – 6.20), after taste (2.87- 5.70), mouthfeel (2.63 – 5.80), and general acceptability of (5.43 – 6.63). The study showed that herbal tea with good physicochemical and sensory qualities could be formulated using soursop, ginger, and lemongrass composite. The formulated herbal tea could find domestic and industrial applications.

Keywords: Soursop, lemongrass, ginger, physicochemical, herbal tea

Introduction

In recent times, composite tea has been used as a medium for promoting and sustaining healthy living. Composite tea is an infusion from blends of plant materials that possessed therapeutic secondary metabolites and are nutraceutical (Akila *et al.*, 2018). Most composite teas are functional beverages formulated from medicinal plants and are often known as herbal teas. Herbal teas are produced from green and dried herbs, flowers, fruits, leaves, seeds, bark, and roots of medicinal plants and sold in a loose form or packaged in bags. Herbal tea formulations are consumed in many parts of the world due to their therapeutic and healing properties (Akila *et al.*, 2018). Aside from water, tea is the most consumed beverage in the world. Many medicinal products are now disseminated to consumers in the form of tea. Lemongrass (*Cymbopogon citratus*) tea has been preferred due to its excellent aromatic property. Infusion of lemongrass gives an aromatic drink with a characteristic lemon flavour (Figueirinha *et al.*, 2008). Lemongrass has numerous health-benefiting essential oils, chemicals, minerals, and vitamins that are known to have antioxidants and disease-preventing properties. Lemongrass whether fresh or dried is a rich source of minerals like potassium, zinc, calcium, iron, manganese, copper, and magnesium. Soursop (*Annona*

muricata Linn) leaf is usually used as a herb that serves as an anti-diabetic, anti-inflammatory, insecticide, antimalarial, anticancer, antibacterial, and antioxidant. Because it is rich in phytochemical components, soursop leaf offers numerous advantages (Hasmila *et al.*, 2019). Ginger (*Zingiber officinale* Roscoe) is a plant in the *Zingiberaceae* family and it has been used in African, Asian, Indian, European, and Middle Eastern in therapeutic practices to cure ailments such as arthritis, stomach distress, asthma, diabetes, and menstrual irregularities, to name a few. There is scientific evidence that ginger can help with nausea and vomiting after pregnancy, surgery, cancer treatment, or motion sickness, as well as evidence that ginger can help with inflammation and pain (Singletary, 2010). The objective of this study was to investigate the physicochemical and sensory characteristics of herbal tea from a composite of soursop, lemongrass, and ginger.

Materials and Methods

Sources and preparation of raw material

Freshly harvested leaves of lemongrass and soursop and rhizomes of ginger were obtained from accredited farms in Unwana Ebonyi State, Nigeria. The leaves were sorted, de-stalked, and cleaned in distilled water (1:90, w/v) to remove dirt and other extraneous materials. The leaves were allowed to drain through a plastic sieve for 30 min and then manually diced into 6 mm. Thereafter, the diced leaves were steamed and dried at 50 °C for 4 h using hot air oven (SM9053, Uniscope, England). The ginger rhizomes was peeled, washed using distilled water, drained, diced, steamed, and oven-dried at 50 °C for 6 h. The dried leaves and rhizomes were milled using an attrition mill and sieved using a mesh of aperture 212 µm. The milled samples obtained from lemongrass, soursop, and ginger were then formulated into herbal tea at different blend ratios. The formulated mixtures were packaged into a tea bag and sealed using an electric impulse sealer.

Physicochemical properties

The densities and porosity were evaluated as stated by Gbadamosi *et al.* (2017). The method of Gulzar (2011) was used to determine the pH using an electronic pH meter (Model PHN-850, Villeur-Banne, France). Total soluble solids were determined using a digital refractometer (Alago PR-100 palette). Colour was evaluated through a chromameter (CR-400/410, Konica Minolta). The tea was investigated for L* (which indicates lightness and ranged from 0-100 representing absolute dark to pure white), a* (degree of redness to greenness 0-60), and b* (degree of yellowness to blueness, 0-60).

Sensory evaluation

The sensory characteristics of the herbal tea were carried out using 40 semi-trained panelists. Tea infusion was made from each formulated sample by suspending the tea bag in boiling potable water at a ratio of 1:50 (w/v) and homogenized. The prepared tea without sugar or milk, was rated using a 9-point hedonic scale with 9 indicating “like extremely and 1 indicating “disliked extremely”. Each panelist was given water to rinse the mouth after each sampling.

Statistical analysis

The experiment was laid out in a completely randomized experiment design was to avoid systematic errors and results subjected to analysis of variance (ANOVA) Evaluation of

significant difference among means considered at a 5% significant level by the Duncan's Multiple Range Test using the SPSS statistical software version 17.

Results and Discussion

The physicochemical properties of tea from blends of soursop, lemongrass, and ginger are presented in Table 1. The loose bulk density ranged from 0.234 to 0.252 g/ml and the packed bulk density ranged from 0.335 to 372 g/ml. These values are less than the bulk densities of green tea from *Camellia sinensis* as 0.584 – 0.609 g/ml reported by Topuz *et al* (2014). The difference may be due to the dryness and particle size as they have been reported to influence loose and packed bulk densities. The highest packed bulk density was recorded for 40%S+20%L+40%G. The porosity ranged from 29 to 37% with the highest recorded for 40%S+20%L+40%G. Porosity describes the percentage of void space in the tea relative to the total volume. The pH of the tea ranged between 5.73 and 5.91. Meanwhile, Suna *et al.* (2018) reported a pH of 3.69 for linden herbal tea whereas Builders *et al.* (2020) reported a pH range of 1.60 – 2.04 for herbal tea from *H. sabdariffa*, *M. oleifera*, and *Z. Officinale*. The total dissolved solids ranged between 4.73 and 6.03 mg/g. Suna *et al.* (2018) reported a value of 7.66 mg/g for the total dissolved solids in linden herbal tea. The colour showed L* as 77.63 – 82.72, a* (1.36 – 2.45), and b* (15.10 – 20.24). Meanwhile, Chen *et al.* (2020) reported values of 73.23 – 79.92 for L*, a* (-0.10 – 0.93), and b* (8.39 – 12.26) for kiwifruit beverage. The L* values of 51.06 – 52.23, a* (-2.50 to -2.77), and b* (14.97 – 19.96) were reported for fermented passion fruit beverages by Santos *et al.* (2021). However, Suna *et al.* (2018) reported values of 13.63, -4.33, and 3.05 for L*, a*, and b*, respectively. Moreover, the values of L* (40.75), a* (-0.78), and b* (6.35) were reported by Atalay and Erge (2017) for white tea and L* (38.21), a* (-1.12) and b* (10.13) for green tea from *Camellia sinensis*. The color of the tea blends studied diverged to red color being that the value of a* was positive. Furthermore, the positive value of b* indicated yellowish color at the values of 18.43, 15.10 and 20.24. The light color of the tea blends could be attributed to low polyphenolic molecules

Table 1Physicochemical characteristics of tea from soursop, ginger and lemongrass blends

Parameter	40%S+20%L+40%G	50%S+25%L+25%G	20%S+40%L+40%G
LBD (g/ml)	0.234±0.001 ^b	0.234±0.001 ^b	0.252±0.001 ^a
PBD (g/ml)	0.373±0.002 ^a	0.335±0.001 ^c	0.353±0.002 ^b
Porosity (%)	37.40±0.10 ^a	30.40±0.34 ^b	29.02±0.02 ^c
pH	5.91±0.01 ^a	5.87±0.01 ^b	5.73±0.02 ^c
TDS (mg/g)	5.26±0.02 ^b	4.73±0.03 ^c	6.03±0.02 ^a
L*	82.72±0.54 ^a	78.93±0.77 ^b	77.63±0.40 ^c
a*	2.45±0.01 ^a	1.80±0.01 ^b	1.36±0.02 ^c
b*	18.43±0.04 ^b	15.10±0.02 ^c	20.24±0.04 ^a

S – soursop; L – lemongrass; G – ginger; LBD – loose bulk density; PBD – packed bulk density; TDS – total dissolved solids

Sensory properties

The sensory attributes of the formulated herbal tea are presented in Table 2. The results

showed that the colour ranged between 6.17 and 7.07 on a 9-point hedonic scale, aroma (4.33 – 6.23), taste (2.83 – 6.20), after taste (2.87- 5.70), mouthfeel (2.63 – 5.80), and general acceptability (5.43 – 6.63). The results indicated that the herbal tea blends were more preferred than the commercial sample in all the sensory parameters except in colour. Moreover, the herbal tea scored above the average in the parameters evaluated. The highest general acceptability was recorded for the sample 40%S+20%L+40%G. Consequently, the developed herbal tea received good acceptability by the panelists and this indicated its wide acceptability if commercialized.

Table 2 Sensory characteristics of tea from soursop, ginger and lemongrass blends

Samples	Colour	Aroma	Taste	After taste	Mouthfeel	Gen. Acc
40%S+20%L+40% G	6.40 ^{ab} ±1.63	6.23 ^a ±1.03	6.13 ^a ±1.85	5.23 ^a ±1.90	5.07 ^a ±2.04	6.63 ^a ±1.65
50%S+25%L+25% G	6.70 ^{ab} ±1.98	6.17 ^a ±1.25	5.93 ^a ±1.82	5.70 ^a ±1.89	5.43 ^a ±1.91	6.57 ^a ±1.79
20%S+40%L+40% G CTS	6.17 ^{ab} ±2.19 7.07 ^a ±1.43	6.17 ^a ±0.82 4.33 ^b ±1.58	6.20 ^a ±1.99 2.83 ^b ±1.00	5.60 ^a ±1.22 2.87 ^b ±1.72	5.80 ^a ±2.12 2.63 ^b ±1.29	6.23 ^{ab} ±1.95 5.43 ^b ±1.79

S – soursop; L – lemongrass; G – ginger; CTS- commercial tea sample

Conclusion

The study showed that herbal tea with good physicochemical and sensory qualities could be formulated using soursop, ginger, and lemongrass composite. Sample 40%S+20%L+40%G was most generally preferred. The formulated herbal tea could find domestic and industrial applications.

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INVESTIGATION ON TOTAL PHENOLIC CONTENT AND ANTIOXIDANT ACTIVITY OF VALUE-ADDED *PUNICA GRANATUM* JUICE.

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ABSTRACT

There has been an increasing demand for fruit juices with probiotic constituents for health promotion and diseases prevention. Fruit juices are considered an appropriate new media for probiotic delivery. *Punica granatum* known as a super fruit was fermented with *Saccharomyces* spp. The pH of the fermented juice, qualitative phytochemical analysis, total phenolic content were determined. The antioxidant activity was also determined by ferric reducing assay and superoxide assay. The pH was found to be 4. Qualitative analysis of phytochemicals revealed the presence of alkaloids, terpenoids, phenols, flavonoids, glycosides, and saponins. Total phenolic content was found to be 96 GAE ($\mu\text{g}/\text{mg}$). The antioxidant activity of value-added pome juice by ferric reducing assay was found to be 77.62 at 700 nm and superoxide assay was 72.92 at 590 nm. Fruit juices are good value-added products to deliver probiotics for people who do not consume milk.

Keywords: Antioxidant activity; Fermentation; *Saccharomyces* spp, Pomegranate juice; Total phenolic content

INTRODUCTION

Punica granatum has been called the king of fruits and a wonder fruit. All the parts of the plant possess therapeutic value and are beneficial in health promotion. Fresh juice of *Punica granatum* constitutes 85 % water and 15 % of sugars, organic acids, pectins, anthocyanins, polyphenols, vitamins, and minerals. The seeds are rich sources of lipids, proteins and punicalagin (Adhami et al., 2013). Plant-derived foods are good remedies for ailments without any adverse effects. Also, they are an affordable effective alternative therapy for many metabolic diseases, including diabetes (Barathikannan et al., 2016)

Punica granatum L belongs to the Puni-caceae family and is the smallest plant family that includes genus and species, including the following: *Punica granatum* (edible pomegranate), indigenous to Iran and Mediterranean regions, and *Punicaprotopunica* (inedible), indigenous to Socotra Islands in the Pacific Ocean

Its flowers, leaves, bark of young shoots and roots, fruit peel, are consumed as traditional medicine. All parts of *Punica granatum* L fruit with abundant tannins show relatively strong astringent effects. Several infusions or decoctions of the plant have been used in traditional medicine to treat simple diarrhoea, and uterine problems, and also this extract accompanied with pomegranate peel has usually been gurgled to relieve pancreas inflammation (Hayganni et al., 2018)

Fermentation of pomegranate juice by yeasts (*Saccharomyces* sp.) and aging results in the

change of sugar to alcohol and native substances into secondary metabolites influencing sensory attributes of the product. Changes occurring during fermentation and their effect on bioactive compounds in pomegranate fruits are mainly because of the interactions of the compounds with yeast cells. The reactions during fermentation may be polymerization, condensation, oxidation, hydrolysis, enzyme activity, and interactions of antioxidants with yeast cell walls. The activity of yeasts during fermentation has a significant effect on phenolics, which modify the organoleptic properties of wine, such as tart taste, color, and aroma

Fermentation using yeasts and lactic acid bacteria changes the chemical composition of juices. The principle active components ellagitannins and anthocyanins are not stable during juice processing, while after fermentation the contents of bioactive components are reduced and at the same time, it improves the stability of the compounds. Thus, fermentation is more beneficial by improving taste and flavor, increasing digestibility, and better bioavailability of nutrients (Malgorzata et al., 2017)

MATERIALS AND METHODS

The study was conducted in the food analysis laboratory of the Food Technology Department, Hindustan Institute of Technology and Science, Chennai, India. Analytical grade chemicals were purchased from Biosar India Ltd.

Preparation of fermented juice

A quantity of 1 and 1/2 kilograms of Pomegranates (*Punica granatum* L.) was purchased from local fruit vendors in Chennai and Yeast (*Saccharomyces cerevisiae*) from an online store sold by sweet king India. To prepare the wine from *Punica granatum*, the fruits were washed and cleaned properly using a dry cloth to remove all possible dirt and contaminants from the fruit. Then it was cut into four parts to easily extract seeds and arils from the fruit. Now, 250 gms of seeds were crushed using a crusher with some amount of sugar (20g) and slightly crushed. The crushed seeds were then added into a sterile glass container with 10 gm of yeast. The glass container was closed with a lid tightly without allowing air to pass into the container. Then the closed container was placed in a dark, cool place until it settled. After settling for 7 days the first fermentation of wine was completed. Then it was filtered using a clean cloth/muslin cloth and set for second fermentation for 14 days to settle. The wine can be stored in bottles and sealed tightly without the passage of air and not allowing sunlight. The prepared sample was tested for alkalinity and phytochemical screening.

Measurement of the pH.

Among the several intrinsic factors that affect the shelf life and spoilage rate of juice, pH is the most influential. Variations of pH can influence flavor, consistency, and shelf life. Fruit juices usually have low pH values that range between 2.0 and 4.5 due to the presence of organic acids that vary within the different types of juices. In order to maintain consistency in the quality of juice, monitoring pH is important. Hence the pH is measured using an automated digital pH meter.

Preparation of test samples Ten ml of fermented juice was subjected to preliminary phytochemical screening by the methods suggested by Trease and Evans, (1989)

Measurement of total phenolic content

The total phenolic content (TPC) of the sample was determined according to Folin–Ciocalteu method. Briefly, 0.2 mL of diluted beverage was added to 1 mL of Folin–Ciocalteu reagent (prediluted 10-fold with distilled water) and shaken well. The mixture was allowed to stand at room temperature for 8 min. Then 0.8 mL of sodium carbonate (7.5 %) was added to the mixture, shaken, and left at room temperature for 30 min. Absorbance was measured at 765 nm in a spectrophotometer (CECIL CE 250). The TPC was assessed by plotting the gallic acid calibration curve and expressed as milligrams of gallic acid equivalents per liter of sample. Eight different dilutions (in the range of 0.22 mg GA/L–80 mg GA/L) were used to get the gallic acid calibration curve. The equation for the gallic acid calibration curve was $Y = 89.014X - 34.479$ (where X = measured absorbance and Y = concentration of gallic acid equivalents expressed as milligrams of GA per liter of sample),

Antioxidant capacity determination

Ferric (Fe 3+) reducing power assay: The ferric reducing power of fermented beverages is measured according to Oyaizu's method (1986). One mL of extract with different concentrations (20 - 120 µg/mL) was mixed with 1 mL of 1% (w/v) potassium ferricyanide [K₃Fe (CN)₆] solution and 1 mL of phosphate buffer (0.2 M, pH 6.6). The mixtures were then incubated at 50°C in a water bath for 20 min. Five hundred µL of 10% (w/v) trichloroacetic acid solution was added to each mixture followed by 1 mL of 0.1% (w/v) freshly prepared FeCl₃ solution was added and shaken well. The absorbance was measured at 700 nm and ascorbic acid was used as the standard reference. The percentage of inhibition was calculated using the following formula:

$$\% \text{ of Fe}^{3+} \text{ reduction} = [(Abs \text{ (sample)} - Abs \text{ (control)}) / Abs \text{ (sample)}] \times 100$$

Superoxide assay:

The antioxidant activities of fermented pome juice were measured by the method described by (Robak and Gryglewski, 1988). Superoxide radicals were generated by oxidation of Nicotinamide adenine dinucleotide. (NADH) and assayed by the reduction of Nitroblue tetrazolium NBT. The reaction mixture 3.0 ml consisted of 1.0 ml of the solvent extract of different concentrations diluted by distilled water, 0.5 ml Tris hydrogen chloride. HCL buffer (16mM, pH 7), 0.5 ml NBT (0.3 mM), 0.5 ml NADH (0.936 mM) and 0.5 ml Phenazine methosulfate (PMS) (0.12 mM). The superoxide radical generating reaction was started by the addition of PMS solution to the reaction mixture. The reaction mixture was incubated at 25°C for min and then the absorbance was measured at 560 nm using UV-VIS Spectrophotometer (Shimadzu, Japan), against a blank sample. The percentage of inhibition was calculated using the formula

Estimation of alcohol content:

$$\text{Ethanol (\% vol/vol)} = 25 - 25[VA/VB]$$

Results and discussion

pH of the fermented juice

The prepared fermented pomegranate juice gave a pH value of 4, which explains its sweet and sour taste. A study conducted by Ferial(2014) showed that the pH of pomegranate juice ranged from 3.4 to 4.3 while a study conducted by Pooja et al.(2017) confirmed that the pH value varied between 4.34 – 5.25 among different cultivars.

Qualitative Phytochemical Screening

The identification of phytochemicals in fermented pomegranate juice is a pivotal onset point for evaluating their biological, nutritional, and technological facets. The fermented juice was screened for the presence of key families of phytochemicals, glycosides, tannins, alkaloids, flavonoids, saponins, and sterols. In general, there are great differences of the phytochemicals between cultivars

Proteins, amino acids, tannins, and flavonoids were present in pomegranate juice as minor components. Whilst, glycosides, alkaloids, saponins, and sterols occurred as trace substances. It is of interest to note that the pomegranate juice of the wonderful cultivar contained higher amounts of carbohydrates, proteins, phenolics, and tannins.

Quantitative estimation of total phenolic content

Quantitative estimation of total phenolic content by Folin– Ciocalteu method was found to be 96 gallic acid equivalents in the calibration curve. Nayereh, et al., 2016 in her study says that TPC increased as the fermentation period extended. These results can be explained by the fact that the metabolic activities of microorganisms in kefir grains can modify the levels of bioactive components such as different phenolic compounds. During fermentation, enzymes such as Beta-glycosidase derived from the fermentative microorganisms are responsible for hydrolyzing complex phenolic compounds to simpler types and increasing quantitative amount of TPC. Other enzymes such as protease derived from the microorganisms or whey can have contributed to the modification of beverage compositions. It has been reported by other researchers that fermentation by lactic acid bacteria or other microorganisms can increase the level of total phenolic content, too.

During fermentation, the concentration of gallic acid increased significantly, which may be explained by the hydrolysis of ellagitannins, as well as other oxidation reactions. The presence of phenols during wine aging has a marked effect on the release of polysaccharides from cell walls during autolysis of yeast cells, while these, in turn, contribute to the modification of sensory attributes of pomegranate wines (ref?)

Antioxidant assay of *Punica granatum* fermented Juice

Ferric (Fe 3+) reducing power assay

In the given sample, the highest concentration for inhibition was found at 120 µg/ml and the percent of inhibition was found to be 77.62. 32.11 % was the percent of inhibition for 20 (µg/ml) concentration. The methanolic or mixture-solvent extracts of peels had better

reducing power than those of water or ethyl acetate. The antioxidant activity has been reported to be concomitant with the reducing power of plant materials. The higher reducing power indicated the presence of reductones which are able to break free radical chains by donating hydrogen atoms and thus converting them to a more stable non-reactive species.

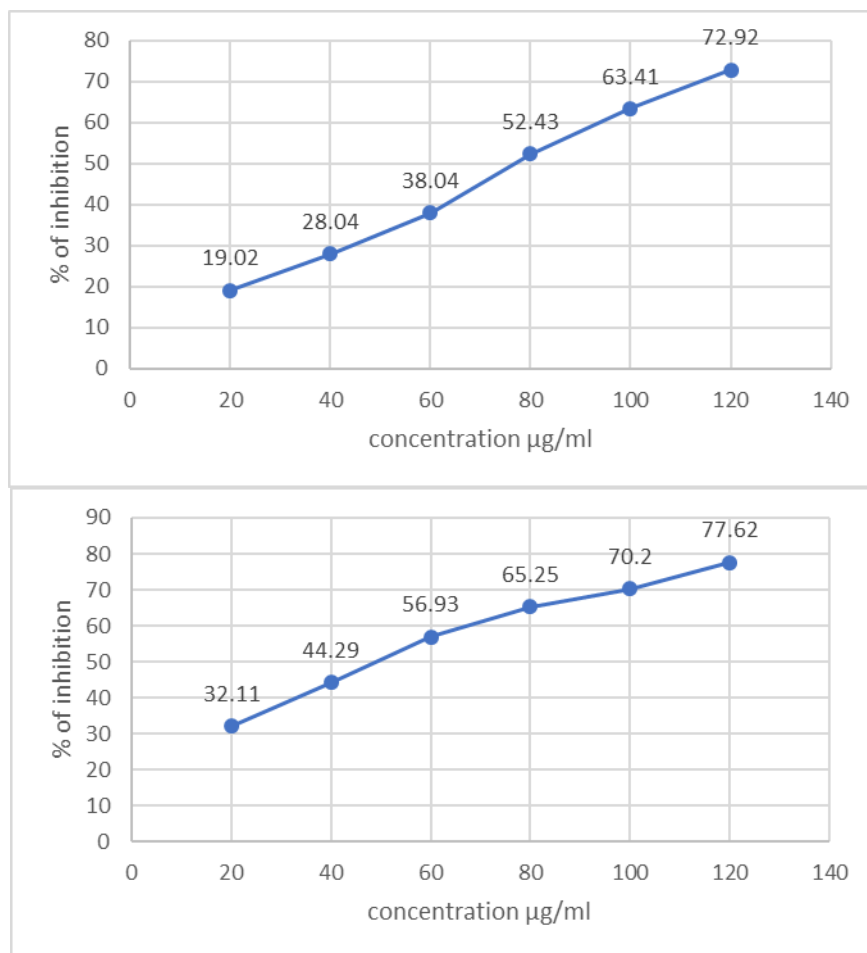


Figure 1: Ferric (Fe 3+) reducing power assay and Superoxide dismutase assay

Superoxide dismutase assay

In the given sample maximum percent of inhibition was 72.92 for 120 (µg/ml) and the minimum inhibition was 19.02 for 20 (µg/ml).

Estimation of alcohol content:

Ethanol (% vol/vol) = $25 - 25[VA/VB] = VA - 9$; $VB - 3 = 25 - 25(0.33) = 25 - 8.33 = 16.7\%$

ABV is the global standard of measurement for alcohol content. The range of ABV for unfortified wine is about 5.5% to 16%, with an average of 11.6%(Snopek, et.al, 2018).

CONCLUSIONS

The results of the present investigation confirmed that the fermentation of

pomegranate juice with *Saccharomyces* species exhibited improved TPC and antioxidant activities. Also, it can be confirmed that fermented pomegranate juice could be used to cure various ailments due to its antioxidant potential. On the basis of this study, it was found that fermentation with *Saccharomyces* reduces the components of the juices, gives better stability to the components of juice, and increases bioavailability. It was found that total phenolic content improved after fermentation and enhanced the antioxidant activities. So, more research can be done on producing novel fermented beverages with pomegranate and *Saccharomyces* which can serve as elixir to mankind.

Table 1: Antioxidant assay

Ferric (Fe 3+) reducing power assay		
CONCENTRATION(µg/ml)	OD at 700nm	% OF INHIBITION
Control	0.205	-
20	0.302	32.11
40	0.368	44.29
60	0.476	56.93
80	0.590	65.25
100	0.688	70.20
120	0.916	77.62
Superoxide dismutase assay		
CONCENTRATION(µg/ml)	OD at 700nm	% OF INHIBITION
Control	0.410	-
20	0.332	19.02
40	0.295	28.04
60	0.254	38.04
80	0.195	52.43
100	0.150	63.41

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YIELD AND PASTING PROPERTIES OF LAFUN FROM CASSAVA ROOTS AT DIFFERENT STORAGE CONDITIONS AND HOLDING TIME

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Abstract

This study investigated the effects of sawdust, trench, polythene bag and cold storage conditions and time (21 days) on the physicochemical properties of *lafun* as the second popular food products of cassava in West Africa. The roots were evaluated at 3-day intervals for physicochemical composition before being processed into *lafun*. The results revealed a varied impact of the storage methods on the chemical composition of the root over the holding period. *Lafun* yield as well as the cyanogenic properties reduced as storage progressed. The cassava stored in the trench and sawdust had the highest *lafun* yield of 31.4 % and 30.1% respectively after 9 days of storage. While the *lafun* yield from the cassava stored in polyethene bag and refrigerator were 27.9 % and 28.2 % respectively, at 9 days storage. This was significantly lower than the yield obtained for fresh roots of 37.2%. However, the increase in the peak viscosity of *lafun* as storage progress suggests an alteration in starch composition due to storage. It could therefore be deduced from the study that cassava stored using trench and sawdust for 21 days and 9 days for polythene bags and cold storage respectively are suitable for *lafun* production.

Keywords: *Lafun*, cyanide, storage condition, yield, pasting properties.

1.0 INTRODUCTION

Cassava (*Manihot esculenta* Crantz) play a key role in the food and chemical industries as an important raw material, the crop serves as food for humans and animals. It is highly drought tolerant, and grows reasonably well in marginal soils (Ezuiet *et al.*, 2018). Despite the benefits of cassava root, it has a short post-harvest shelf life which limits their potentials in the market and their benefits to cassava farmers. Physiological deterioration occurs in cassava roots 2-3 days after harvesting, followed by microbial deterioration 3-5 days thereafter (Karim *et al.*, 2021; Akingbala *et al.*, 2005).

Storage of cassava roots before usage for starch and flour has also been found to influence the physicochemical properties of the final product (Oyeyinka *et al.*, 2020). Several modern storage methods have been developed to mitigate the problem of cassava root deterioration like refrigeration, freezing, waxing and chemical protection, including extending time of harvesting after maturity, burying of freshly harvested roots in the soil, storing in trench etc. aimed at reducing the rate of deterioration (Karim *et al.*, 2009; Oyeyinka *et al.*, 2019). However, most of the modern methods may not be economically viable for storing of high volume of cassava roots prior to processing to major products like *gari*, *lafun* and *fufu*.

(Karimet *et al.*, 2009).

A careful search showed that there is dearth of literature on the yield, chemical and pasting properties of *lafun* produced from cassava stored under traditional storage methods. It is therefore important to consistently evaluate the appropriateness of some traditional storage methods for cassava roots meant for *lafun* production. The study therefore investigated the effect of 21 days storage of cassava roots on the yield and pasting properties of *lafun*.

2.0 MATERIALS AND METHODS

2.1 Material collection

Fully matured (18 months) cassava roots (TMS 30001; *okoijam* variety) obtained from the Teaching and Research Farm, Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State was used for this study. The roots were carefully harvested to minimize mechanical damage to the roots. Harvesting of the roots was done with part of the stem (2 – 5cm) still attached to limit ingress of any decay into the roots.

2.2 Storage Preparation

The trench used was 4ft long, 3ft wide and 5ft deep. The cassava roots were arranged in the trench in layers with palm fronds placed between each layer and above the third layer before covering up with soil. While the sawdust box storage was done using the storage method described by NSPRI (1995). Wooden boxes of dimension 30cm X 26cm X 24cm were used for sawdust storage.

The sawdust was moistened by mixing it with clean water at ratio 3:1 as reported by Olaleye *et al.* (2013). Polythene bags of 0.64 mm thickness was used (Tomlinson *et al.*, 2021). The tubers were arranged carefully such that there was no contact between the roots to prevent abrasion injury and cross contamination.

Cassava roots were stored under refrigeration conditions. A digital thermohygrometer (decagon Aqualab 3TE) was placed in each storage media to record the temperature and relative humidity through the holding time.

2.3 Pasting Properties

The pasting properties of cassava roots were determined by using Rapid ViscoAnalyzer (RVA) as described by Chandanasree *et al.* (2016). Parameters recorded included peak viscosity (PV), trough viscosity (TV), breakdown viscosity (BV), final viscosity (FV), setback viscosity (SV), pasting temperature (pt) and peak time (PT).

2.4 Determination of Cyanide Content of Cassava Roots

The hydrogen cyanide (HCN) content of the cassava flour was determined as described by Essieret *al.*, (1993). The data obtained from the blank was used in obtaining a standard curve and its slope (b) by plotting absorbance values (Y-axis) against standard concentrations (x-axis).

2.5 *Lafun* Yield Determination

Lafun yield was determined by the method of Akingbala et al., (2005). **This was taken as the percentage weight of *lafun* obtained per weight of unpeeled cassava roots. Samples were analysed at 3days interval for a period of 21 days.**

2.6 Statistical Analysis

All analytical determinations were done in triplicates. Data were subjected to statistical analysis of variance (ANOVA) using SPSS version 10.0. Means were separated using Duncan Multiple Range Test (DMRT).

3.0 RESULTS AND DISCUSSIONS

3.1 *Lafun* Yield

The lowest value of 24.7% was obtained as the *lafun* yield for the roots stored in polyethylene bag at the end of 12 days storage, while 25.1% and 26.3% was recorded as the *lafun* yield, for the roots stored in sawdust and trench respectively at the end of 21 days. However, the yield of *lafun* from fresh cassava roots was 37.2% and 31.7% at day 1 and 3 respectively. Sanni *et al.*, 1990; Karimet *al.*, 2009 reported that *gari* yield of cassava root should not be less than 25%. This corresponds with the result obtained for *lafun* yield. Therefore, the results showed that the sawdust and trench storage could support cassava root meant for *lafun* production for 21 days while polyethylene bag and refrigerator could only support storage of cassava roots meant for *lafun* production, for about 9 days. The lower yield with increasing storage period may be attributed to difficulty of peeling due to moisture loss and greater loss of the pulp as the peel. The microbial spoilage of the pulp may be responsible for the observed variation.

3.2 Cyanogen concentration

The cyanogenic properties of *lafun* reduced (Fig. 1) with increase in storage period for all the storage methods for the cassava roots. This is however expected with the reduction in carbohydrate, pH and moisture content of the roots. The cyanide concentration value for *lafun* at the end of the storage period of the roots were 1.9, 2.2, 8.1, 8.2 and 10.2 mg/kg for trench, sawdust, cold storage, polythene bags and open storage respectively. The cyanide concentrations are below the NIS standard for cassava flour of 10mg/kg except for open

storage.

Fig. 1: Cynogenic concentration of *lafun* from cassava at different storage methods and holding period

3.3 Pasting Properties of *Lafun* Flour

The mean values of peak viscosity, peak time and pasting temperature ranged from 120.42 to 414.35 RVU, 3.12 to 5.40 min and from 73.15 to 79.15°C, respectively. The interactive effect of storage conditions and duration was significant ($p < 0.05$) on all the pasting properties. There were gradual increase in peak, trough, breakdown, and final viscosities with storage time. The increase in peak viscosity with storage time indicates close association between amylose and amylopectin in the native granules of starch and stronger associative forces maintaining the granules structure, higher peak viscosity is an indication of high starch content and also relate to the water-binding capacity of starch (Oyeyinka *et al.*, 2019). The method of storage might have altered the starch content and structure of the cassava roots. Higher peak viscosity has also been reported in starch from refrigerated cassava compared with fresh cassava (Oyeyinka *et al.*, 2020), oven-dried cassava roots compared with *lafun* from sundried roots (Taiwo *et al.*, 2016). Generally, *lafun* from stored cassava showed higher breakdown viscosity compared to *lafun* from freshly harvested roots. This implies that *lafun* from freshly harvested roots is more stable to heat and mechanical shear than *lafun* from stored roots. The initial values before storage of the cassava flour for the setback viscosity was 71.72 RVU, the highest setback viscosity 81.90 RVU was recorded at day 6 with sawdust storage, while the lowest setback viscosity 45.19 RVU was recorded at the day 21 in trench storage. A lower setback viscosity values indicate that the flour would have a high paste stability and resistance to retrogradation upon cooling (Sanni *et al.*, 2006; Etudaiye *et al.*, 2009). The storage periods and condition had a significant effect ($p < 0.05$) on the pasting temperature.

Final viscosity indicates the ability of the flour to form starch and viscous paste or gel after cooking and cooling (Maziya-Dixon *et al.*, 2007). The final viscosity ranged from 172.22 to 382.16 RVU. There was a significant ($p < 0.05$) difference in the final viscosity of *lafun* from stored cassava.

Table 1: Changes in pasting properties of cassava roots under different storage conditions and duration

Storage	Days	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown Viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (Min)	Pasting temperature (°C)
Open	0	120.42 ^h	170.28 ^e	91.83 ^g	243.04 ^f	72.72 ^{ab}	5.40 ^a	75.90 ^d
	3	356.71 ^d	11.83 ^f	177.88 ^b	194.11 ^h	51.69 ^d	4.76 ^b	78.20 ^a
Sawdust	0							
	3	352.81 ^d	121.72 ^g	93.68 ^f	175.88 ⁱ	49.84 ^d	4.19 ^c	78.20 ^a
	6	327.03 ^e	220.25 ^a	95.44 ^f	302.17 ^e	81.90 ^a	5.47 ^a	78.20 ^a
	9	335.10 ^e	171.38 ^e	106.08 ^e	321.02 ^d	61.25 ^c	4.91 ^a	77.64 ^b
	12	333.91 ^e	186.42 ^d	114.06 ^e	346.21 ^c	60.08 ^c	4.83 ^b	73.82 ^e
	15	372.85 ^c	189.64 ^d	128.37 ^d	382.16 ^a	52.19 ^d	3.61 ^c	76.84 ^b
	18	395.07 ^b	204.32 ^b	157.08 ^c	361.27 ^b	50.48 ^d	4.42 ^b	75.02 ^c
	21	414.35 ^a	224.81 ^a	194.82 ^a	374.33 ^{ab}	47.63 ^{de}	3.73 ^d	74.91 ^d
Trench	0							
	3	324.75 ^f	127.20 ^g	108.07 ^e	176.58 ⁱ	79.58 ^a	4.52 ^b	73.15 ^e
	6	305.67 ^g	160.28 ^d	119.32 ^e	182.42 ^{gh}	65.83 ^b	4.57 ^b	77.25 ^b
	9	321.81 ^f	184.68 ^d	128.64 ^d	194.36 ^h	53.78 ^d	4.20 ^c	78.85 ^a
	12	378.24 ^c	187.53 ^d	137.20 ^d	225.51 ^g	51.48 ^d	3.12 ^d	77.62 ^b
	15	334.81 ^d	196.21 ^c	141.32 ^c	234.74 ^f	47.66 ^{de}	4.17 ^c	78.41 ^a
	18	379.62 ^c	196.45 ^c	145.08 ^c	245.32 ^f	49.14 ^d	3.87 ^c	77.73 ^b
	21	405.08 ^a	203.22 ^b	187.75 ^a	328.43 ^d	45.19 ^e	3.66 ^c	76.08 ^c
Polythene Bag	0							
	3	371.24 ^c	128.91 ^g	97.64 ^f	181.82 ^{hi}	46.83 ^e	4.74 ^b	77.61 ^b
	6	356.25 ^d	209.33 ^b	101.84 ^f	292.67 ^e	83.33 ^a	5.13 ^a	77.50 ^b
	9	359.48 ^d	228.11 ^a	146.92 ^c	321.81 ^d	67.45 ^b	4.83 ^b	75.12 ^c
	12	363.81 ^d	236.48 ^a	193.21 ^a	325.21 ^d	58.45 ^c	3.94 ^c	75.08 ^c
Refrigeration	0							
	3	327.87 ^e	130.43 ^{fg}	121.81 ^d	172.22 ⁱ	47.09 ^e	3.74 ^c	78.36 ^a
	6	362.50 ^d	199.33 ^c	163.11 ^b	229.17 ^g	69.83 ^b	4.73 ^b	79.15 ^a
	9	374.85 ^c	207.43 ^b	193.86 ^a	284.30 ^e	54.32 ^d	3.74 ^c	78.11 ^a

Any two means in the same column with different letters are significantly different ($p < 0.05$) according to DMRT.

4.0 CONCLUSION

This report showed that the shelf life of cassava roots can be extended for up to 21 days using trench and sawdust storage methods, 12 days for polythene bag and 9 days for cold storage for acceptable yield of *lafun*. The interactive effect of storage conditions and duration was significant ($p < 0.05$) on all the pasting properties. There was gradual increase in

peak, trough, breakdown, and final viscosities with storage time. The final cyanogen concentration across the storage methods are below the acceptable level. Conclusively, trench and sawdust storage media are more acceptable storage methods for cassava intended for *lafun* production for a maximum of 21 days.

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PRODUCTION AND SENSORY EVALUATION OF *KUNUN-ZAKI* FLAVOURED WITH LEMON JUICE

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Abstract

Kunun-zaki is a non-alcoholic fermented beverage known for its nutritional benefits and mostly made from cereal grains. However, it has a sweet-sour taste and short shelf life of about 24 hours. The acidic nature and healthy components of lemon fruit juice amongst its pleasant flavour, qualifies it as a natural food additive. Therefore, this work is aimed at the production and sensory evaluation of *kunun-zaki* flavoured with lemon juice. Sorghum grains were steeped for 24 hours, then wet milled together with dried sweet potato chips, cloves and ginger. Boiling water was added to two-third of the paste, stirred and cooled to 40 °C. After which, it was mixed with the remaining one-third paste and stirred, then allowed to ferment for 10 hours at 35 °C. The *kunun-zaki* was stirred, filtered and divided into three (3) portions of 1L each. Lemon Juice (50 ml) was added to one portion, 100ml to another and the third portion was the control. The samples were subjected to sensory evaluation test. Overall acceptability significantly decreased (6.97 to 6.10) as lemon juice quantity increased from 50ml to 100ml. Therefore, *Kunun-zaki* flavoured with lemon juice was successfully produced and accepted.

Keywords: *Kunun-zaki*, Lemon juice, Food flavour, Sorghum, Healthy beverage

Introduction

Kunun-zaki is a cereal based non-alcoholic fermented beverage, mostly consumed in the Northern part of Nigeria (Abiodun *et al.*, 2017). It can be produced either from millet (*Pennisetum typoidum*), sorghum (*Sorghum bicolor*), or maize (*Zea mays*). *Kunun-zaki* is nutritionally rich in protein (9 – 11%), minerals and vitamins; the nutrient values differ resulting from factors such as ingredients used and processing methods. It also has good digestibility attributes, probiotic as well as sweet-sour taste (Victor-Aduloju *et al.*, 2018). Being a locally processed beverage made from natural sources in addition to its health benefits, *kunun-zaki* is preferred over the consumption of synthetically processed beverages (Inetianboret *et al.*, 2015). However, *kunun-zaki* is faced with the challenge of its sweet-sour flavour, in addition to short shelf life of about 24 hours, without pasteurization and refrigeration. This has limited its increasing demands and production as product varieties need to satisfy recent dynamic consumers' taste, is important. Furthermore, owing to the increasing awareness to reduce consumption of synthesized food additives due to some associated health concerns, the need to utilize natural-healthy food ingredients is paramount (Mesias *et al.*, 2021).

Lemon fruit (*Citrus limon*) is high in essential nutrients and phytochemicals including flavonoid and vitamin C, with a pH range of 2 -3, it is an antimicrobial (preservative) agent used in

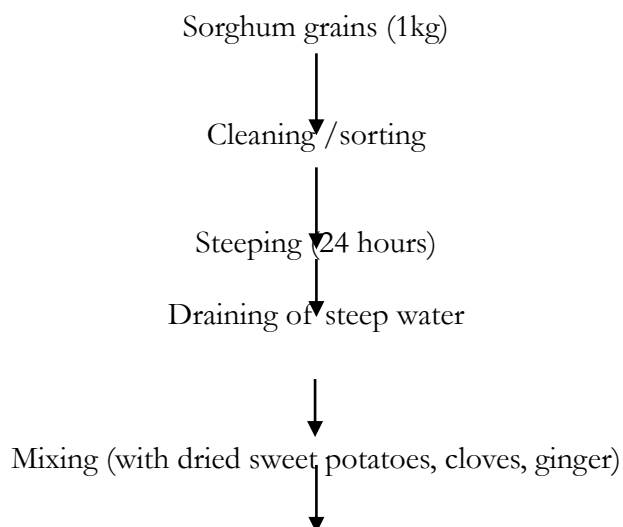
food and beverages (Lorentet *et al.*, 2014). Also, lemon juice possesses pleasant flavours and antioxidants hence, adding it to foods contributes positively to taste, health and shelf life of that product (Okokon and Okokon, 2019). Moreover, increasing lemon fruit utilization in food processing will go a long way in reducing its post-harvest losses in Nigeria. Thus, this study was aimed at production and sensory evaluation of *kunun-zaki* flavoured with lemon juice.

Materials and Methods

Sorghum (*Sorghum bicolor*), dried sweet potato (*Ipomoea batatas*) chips, cloves (*Syzygium aromaticum*), ginger (*Zingiber officinale*) and lemon (*Citrus limon*) fruits were obtained from new Market, Enugu metropolis, Enugu state, Nigeria.

The method described by Abiodun *et al.*, (2017) was used to produce *kunun-zaki*, with some modifications. Sorghum grains (1 kg) was sorted, washed and steeped in 2000 ml potable water (1:2, w/v) for 24 h at 35 °C. The steep water was drained and the grains washed twice. Dried sweet potatoes (50 g), cloves (2 g) and ginger (20 g) were added to the sorghum and all wet milled together. The resulting paste was divided into two unequal portions (1:3 v/v). Boiling water (1000 ml) was added to the larger portion of the paste to gelatinize it, then stirred properly and allowed to cool to 40 °C. Next, the ungelatinized (smaller) portion was added and mixed evenly to form *kunun-zaki* slurry. Afterwards, the slurry was allowed to stand and ferment for 10 hours at 35 °C. Water (500 ml) was added to the fermented *kunun-zaki* to aid filtration, then stirred, sieved through 350 µm diameter mesh and sweetened with 100 g of granulated sugar.

Lemon fruits were washed with potable water, peeled and sliced into halves using a sterile knife. A manual citrus fruit squeezer was used to extract the lemon juice into a clean sterile beaker, and sieved to separate the juice. Then, the freshly prepared *kunun-zaki* was divided into three (3) portions of 1 L each. Lemon Juice was immediately added; 50 ml in one portion (Kf), 100 ml in another portion (Kh) and the third portion without lemon juice was left as control (Kz).



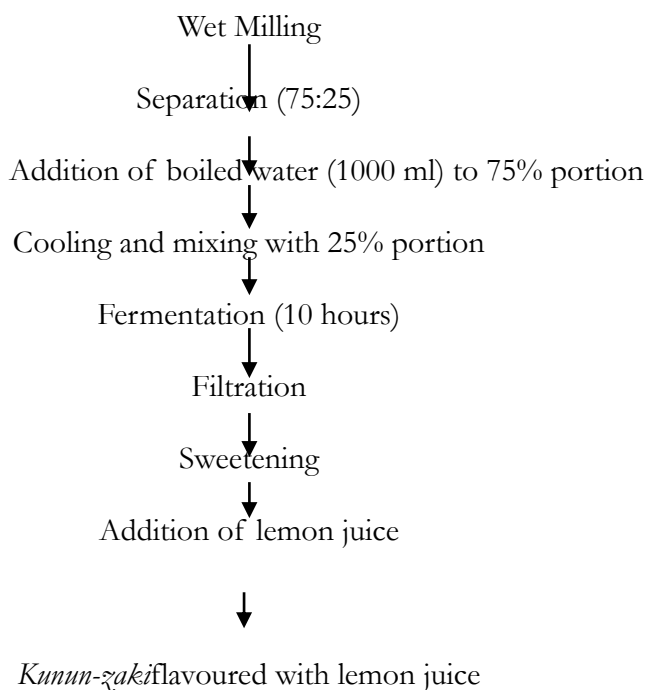


Figure 1: Flow chart for the production of *Kunun-zaki* flavoured with lemon juice

Sensory analysis of the *kunun-zaki* flavoured with lemon juice was carried out immediately after preparation by selecting 20 trained panelists among the students and lecturers of Department of Biological Sciences, Godfrey Okoye University, Enugu, Nigeria. The panelists were requested to examine the coded *kunun-zaki* samples and score according to their degree of likeness with a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The parameters evaluated were the appearance, taste, texture, and overall acceptability (Onyimba and Dishon, 2019).

Statistical analysis was carried out in triplicates and the data collected were evaluated for significant differences of their means with analysis of variance (ANOVA) ($p \leq 0.05$). Mean separation was carried out using Duncan's (1955) multiple range test for the Least Significance Difference (LSD).

Results and Discussion

Table 1: Mean sensory properties of *kunun-zaki* flavoured with lemon juice

Sample	Appearance	Taste	Texture	Overall acceptability
Kf	4.93 ^a	6.95 ^{ab}	6.70 ^a	6.97 ^a
Kh	5.05 ^a	5.80 ^b	5.77 ^b	6.10 ^b
Kz	5.10 ^a	7.85 ^a	6.88 ^a	6.92 ^a
LSD	1.08	1.11	0.89	0.36

Means in the same column with same superscript letters are not significantly different at $p \geq 0.05$

Key; Kf – samples with 50 ml lemon juice; Kh – samples with 100 ml lemon juice; Kz – samples without lemon juice (control)

Sensory evaluation showed no significant difference among the samples for appearance, but the appearance mean score of 5.03 indicates that the average participants neither liked nor disliked the appearance. While, the samples flavoured with 100 ml lemon juice (Kh) showed the least significant values for taste, texture and overall acceptability as 5.80, 5.77 and 6.10 respectively. This implies that panelist preferred the control samples with the highest figures except for overall acceptability where Kf samples showed the highest value of 6.97. Kf Samples can be accepted as a substitute as no significant difference was observed between them. Indicating that, increasing the lemon juice quantity in the *kunun-ṣaki*, decreased its sensory properties. Therefore, the need to strike a balance between increasing food flavour-varieties and sensory acceptability is paramount to the successful growth of that food product. These sensory scores were higher than the values reported by Onyimba and Dishon, (2019) for the preservation of *kunun-ṣaki* with lemon juice and honey, their overall acceptability values ranged from 3.80 to 5.00.

Conclusion

The production of *Kunun-ṣaki* flavoured with lemon juice was successfully achieved. Findings of this study indicates an overall acceptability of its sensory attributes at the addition of 5 % or 50 ml lemon juice per liter of *Kunun-ṣaki*.

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**ASSESSMENT OF HEAVY METALS IN WATERMELON
(*CITRILLUSLUNATUS*) KAOLACK VARIETY AND IRRIGATION WATER: A
CASE STUDY OF JANZOMO AND GWADANGAJI RIVER. KEBBI STATE,
NIGERIA.**

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Abstract

Heavy metals are non-biodegradable metallic elements with relatively high density and are poisonous at relatively low concentrations. The aim of this study was to assess the heavy metal content of watermelon (rind, seed and pulp) and water used for irrigation in watermelon farms in Gwadangaji and Janzomo, Kebbi state, Nigeria. Mass plasma Atomic Emission Spectrophotometer (MP-AES) was used to determine the concentrations of Zinc (Zn), Cadmium (Cd), Nickel (Ni) and Lead (Pb) in the samples. Values obtained for these metals were in the ranges of Zinc (0.289 ± 0.64 - 10.29 ± 0.7 mg/kg), Ni (0.06 ± 0.02 - 1.47 ± 0.64 mg/kg), Cd (0.00 ± 0.00 - 0.61 ± 0.002 mg/kg) and Pb (0.17 ± 0.06 - 0.88 ± 0.40 mg/kg) in the rind, pulp and seed as well as water used for irrigation in both farms. Zn and Ni values were within the maximum permissible limits set by FAO and WHO while Cd and Pb were found to be above these limits. This study indicates that watermelon grown in the study areas are not safe for human consumption with respect to their cadmium and lead content. Therefore, remediation efforts should be put in place in order to ameliorate the health hazards that may occur as a result of consuming watermelon from these areas.

Key Words; Watermelon, Heavy Metals, Irrigation Water

Introduction

Watermelon (*Citrillusslunatus*) belongs to the *curcubataceae* family. It is a large fruit of more or less spherical or oval shape with a pale to dark green hard rind. It has a sweet juicy refreshing flesh containing multiple pips. Watermelon has been reported to have diverse nutritional and medicinal benefits while the seeds and rinds are mostly used for medicinal purposes (Mbata *et al.*, 2016). The watermelon fruit has its origin from Asia with China being the world's largest producer. In Nigeria, watermelon is mostly grown all year round in Northern Nigeria because of the warm climate limiting cultivation of the crop to seasonal in southern parts of the country (Baba *et al.*, 2014). Kebbi state is one of the major watermelon producing states in North-western Nigeria with a profitability of 55.1%, making watermelon farming a viable income generating venture and a means of poverty alleviation. This therefore implies availability, accessibility at low cost and its increased consumption especially in areas where the fruit is grown. However, watermelon farming involves modern farming methods for enhanced and sustainable food security as such it involves the use of pesticides (Osesua *et al.*, 2018), herbicides, compost manure and synthetic fertilizer which have been indicated to be sources of Heavy metals in agricultural soils.

Heavy metals are non-biodegradable metallic elements with relatively high density and are toxic or poisonous even at low concentrations (Ugonna *et al.*, 2020). Heavy metals contamination when accumulated poses a major human health risk through dietary intake of food crops contaminated by root transfer from soil to tissues or direct deposition on plant surfaces. Prabhat *et al.*, (2019), reports that Nigeria has a high soil-crop subsystem affected by waste water, irrigation and sludge amendment patterns with attendant food safety and ecological consequences that encourage Heavy metal contamination, concomitantly changing the physiology and biochemistry of crop plants thereby posing health hazards. Consumption of fruits and vegetables contaminated with Heavy metals causes serious health issues such as gastroenteritis, gastrointestinal cancer, fragile immunological mechanisms, mental growth retardations and malnutrition (through depletion of essential nutrients) and weakened immunological defences.

A recent Nationwide review of Heavy metals contamination in Nigeria based on fragmented and localised research reported that Lead (Pb), Zinc (Zn), Chromium (Cr), Iron (Fe), Manganese (Mn), copper (Cu), Cobalt (Co) and Nickel (Ni) are predominant contaminants on food chain in Northern states of Kano, Kaduna, Kogi (Itakpe), Borno (Ngada river), Nasarawa (Lafia), (Ugonna *et al.*, 2020). Data to this effect is lacking in Kebbi state, this therefore prompted this research in Order to address the gap in information as well as provide a scientific basis for guiding the local populace and stake holders of the risk or otherwise associated with consumption of water melon from the study area. Results of this research will also provide an insight into the Heavy metal toxicity status of Janzomo and Gwadangaji watermelon as well as the water used for irrigation in these farm lands. Hopefully, information generated from this research, will guide stakeholders in the environmental and health issues on proper food safety and enhanced policy making

STUDY AREA; Gwadangaji and Janzomo are located in the outskirts of Birnin Kebbi town, Kebbi state, Nigeria. Located at $12^{\circ} 27' 57.8808''$ N and longitudes $4^{\circ} 11' 58.2864''$ E. Vegetation is an intermix of Sudan and Guinea savannah an average rainfall of 787.53 mm. Rainfall spans from late April to early October with peak periods in July, August and September (Salihuet *et al.*, 2020). The main occupation of the people of this area is farming.

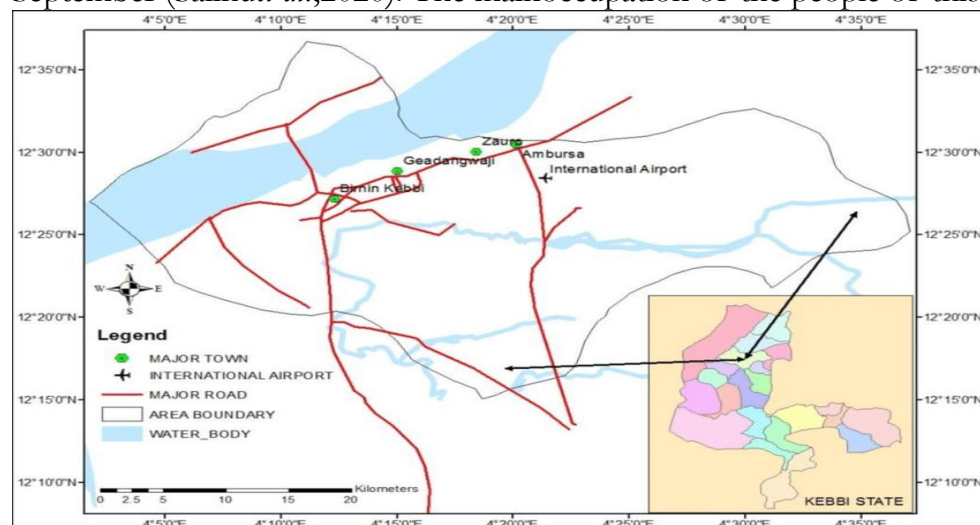


FIGURE 1: A map of Birnin Kebbi showing the study area.

MATERIALS AND METHODS

Sample Collection:

Watermelon (Kaolack) samples were collected from 3 farms (in triplicate) each in Gwandagaji and Janzomo. The samples were wrapped and marked separately and transported to the Biochemistry Laboratory of Department of Science Laboratory Technology Waziri Umaru federal Polytechnic Birninkebbi

Sample preparation and digestion:

Individual watermelon samples were washed severally with distilled water, placed on sterile trays, peeled and cut into pieces. The Pulps and rinds were homogenised and 30mls of each of the samples were collected as aliquot in triplicates. 2g of the seeds were ground. All samples were digested using 10% concentrated HNO_3 v/v followed by wet acid digestion in 10ml 1:3 mixture of Conc. HCl. HNO_3 (Merck) until clear solutions were obtained. Samples were filtered, made up to 50mls with distilled water and stored in clean dry and tightly covered plastic bottles (Oladele and Adesanmi, 2020).

Heavy Metal analysis:

Analysis of metals of interest was carried out using Mass Plasma Atomic Emission Spectrophotometer (MP-AES).

Statistical analysis:

Data generated was subjected to one-way analysis of variance (ANOVA) and Turkey post-test. Differences between means were considered not significant at $P > 0.05$.

Result and discussion

Results of heavy metals (Zn, Ni, Cd, Pb) assessment of the watermelon samples from Gwandagaji and Janzomo as well as irrigation water from these farms are presented in tables 1 and table 2 respectively. Though these results indicate variations in the heavy metals analysed, the differences in heavy metal concentrations in the two farms was not statistically significant at $p < 0.05$.

Table 1: Heavy metals concentration in watermelon from Gwandagaji and Janzomo

ELEMENT	Pulp	Seed	Rind
Gwandagaji samples			
Zn	10.27±0.73a	7.43±0.85b	6.45±0.67b
Cd	0.12±0.04a	0.61±0.23a	0.23±0.01b
Ni	1.47±0.06a	0.48±0.02a	0.94±0.04a
Pb	0.88±0.04a	0.46±0.027b	0.86±0.040a
Janzomo samples			
Zn	7.51±3.42a	7.10±0.29a	6.38±1.76a
Cd	0.00±0.00a	0.04±0.02a	0.17±0.05a
Ni	1.32±0.31a	1.31±0.53a	0.97±0.36a
Pb	0.57±0.18a	0.57±0.29b	0.85±0.12a

Values are expressed as mean $\pm$ standard deviation of $n=3$. Values with the same superscript in a column are not significantly different at $P < 0.05$.

Table 2: Heavy metals concentration in irrigation water from Gwadangaji and Janzomo

Elements	Gwadangaji	Janzomo	WHO standard/limit
Zn	3.28±1.69c	2.89±0.64b	99.4
Cd	0.31±0.01b	0.00±0.00a	0.2
Ni	0.06±0.02b	0.48±0.28b	67.9
Pb	0.17±0.06a	0.25±0.05b	0.3

Values are expressed as mean $\pm$ standard deviation of n=3. Values with the same superscript in a column are not significantly different at $P < 0.05$.

Zinc (Zn)

Zinc is involved in a large number of enzymes or as a molecular structure stabilizer of sub cellular constituents and membranes. Zn participates in synthesis of carbohydrates, lipids, proteins and nucleic acids. It plays an essential role in polynucleotide transcription and translation and thus in the process of genetic expression. It is important in cell proliferation, differentiation and metabolic activity of the cell as well. In addition, it supports growth and development during pregnancy, childhood and adolescence. Humans are very tolerant to high zinc intake, up to 100mg/day (Aliasgharpour, 2020). Zinc intake from contaminated food or beverages and acute zinc poisoning has been associated with non-specific gastrointestinal symptoms such as abdominal pain, diarrhoea nausea, and vomiting (King and Klein, 2000). Long term exposure to high zinc intakes have been shown to interfere with metabolism of trace elements e.g. Cu absorption. Both Type-1 and Type-2 diabetics can exhibit hyperzincuria, which may have a role in the immune dysfunction associated with Diabetes mellitus (Aliasgharpour, 2020). Concentration of zinc from samples ranged from 6.38 ± 1.76 - 7.51 ± 3.42 mg/kg for Gwadangaji samples and 6.45 ± 0.67 - 10.29 ± 0.73 mg/kg for Janzomo samples, while water used in the farm contained 3.28 ± 0.16 and 2.89 ± 0.064 respectively. These values are within the maximum permissible values (99.4mg/kg) established by WHO/FAO (Mensah *et al.*, 2009). Concentration of zinc observed in this research is higher the values obtained (5-9m/kg) for orange samples 3.175mg/kg for fruits in Kano, 0.507mg/kg in Yola (Chiroma *et al.*, 2020) and lower than the values (13.5mg/kg) for tomatoes, 16.75mg/kg for onions obtained by Ugunna *et al.*, 2020. However, values obtained for irrigation water in the study areas were observed to be above the permissible limits (≤ 2.0 mg/l) as established by WHO, (2007) but similar to values obtained by Anwar *et al.*, (2016).

Cadmium (Cd)

Cadmium occurs as a natural constituent in the earth's crust along with Copper, Nickel, Lead and Zinc. Bioaccumulation of cadmium in human body by food chain leads to acute and chronic intoxication due to bio magnifications. Cadmium toxicity may be related to various cancer, including breast, lung, prostate, nasopharynx, pancreas and kidney cancers. It may also be a risk factor for osteoporosis. Other health effects include diarrhoea, stomach pains,

one fracture, reproductive failure and possibly infertility, damage to the central nervous and immune systems, physiological disorders and transformation of normal epithelial cells into carcinogenic cells by inhibiting biosynthesis of proteins

Concentrations of Cadmium ranged from 0.23 ± 0.01 - 0.61 ± 0.02 mg/Kg for the Gwadangaji, these values are higher than the permissible limits (0.2 mg/Kg) set by WHO/FAO, (Mensah, 2009). 0.04 ± 0.02 - 0.17 ± 0.05 mg/Kg recorded for the Janzomo samples are similar to the findings of Oladele and Adesanmi, (2020).

Nickel (Ni)

Nickel is a transitional element extensively distributed in the environment, air, water and soil. Its functional role as trace element for animals and humans has to yet been recognised. It can cause side effects such as allergy, cardiovascular & kidney diseases, lung fibrosis, lung and nasal cancer. Although the molecular mechanism of nickel induced toxicity are yet to be clear, mitochondrial dysfunctions, and oxidative stress are thought to have a primary and crucial role in the toxicity of this metals (Genchiet *al.* (2020).

Values of Ni obtained from these results indicate that the concentration of Ni ranged from 0.48 ± 0.029 - 1.47 ± 0.06 for Gwadangaji farm and 0.97 ± 0.36 - 1.32 ± 0.031 from Janzomo farm. These values fall within the maximum permissible limit (67.9 mg/kg). The values detected are similar to those obtained by Oladele & Adesanmi, (2020) for street vended slide water melon (0.20 ± 0.01 - 1.42 ± 0.02 mg/kg) and lower than values obtained by Orisakwe *et al.*, (2012) for paw-paw 5. g mg/kg.

Lead (Pb)

Lead as a heavy metal that disrupts the endocrine system, Pb is associated with adverse human cardio metabolic outcomes such as high blood pressure, increased body mass index and high cholesterol (Gukadowr, 2014). Values of lead in water melon samples ranged from 0.57 ± 0.018 - 0.88 ± 0.040 . These values exceed the maximum permissible limit of (0.3 mg/kg) as reported by Mensah *et al.*, (2009). However, lead content of 0.17 ± 0.06 and 0.25 ± 0.05 mg/l respectively observed for Gwadangaji and Janzomo water are below standard permissible limits of (<3.0 mg/l) by (WHO, 2007). These values differ from reports of Oladele and Adesanmi, (2020) that detected no lead in sliced water melon samples in Akure.

Conclusion

Findings of this study reveal that water melon fruit grown in Gwadangaji and Janzomo in Kebbi state contain high levels of Cadmium and Lead and are therefore considered not safe for consumption. Measures should be put in place in order to forestall further accumulation of these metals in the farms and the consequent health hazards associated with their consumption.

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ASSESSMENT OF MICRONUTRIENT COMPOSITION, PHYTOCHEMICAL AND SENSORY PROPERTIES OF NON-ALCOHOLIC DRINKS FROM TIGERNUT, COCONUT AND DATE PALM BLENDS

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Abstract

This study aimed at producing a nutritious and healthful drink from the blend of tiger nut, coconut and date fruits. Fresh tiger nuts, coconut and date fruits were cleaned, pulverized, blended, and sieved to obtain their extracts separately. The tiger nut milk, coconut milk and date extract were mixed in varying proportions of 100:0:0, 90:5:5, 80:10:10, 70:15:15, 60:20:20, 50:25:25 and 0:100:0. The blends were homogenized, bottled and pasteurized. The drinks were subjected to mineral, vitamin, phytochemical and sensory attributes evaluation. The data obtained were subjected to analysis of variance. The result showed that the mineral composition of the drink ranged from 59.10 to 80.13 mg/100g; 65.33 to 92.08 mg/100g; 77.82 to 92.03 mg/100g and 7.46 to 23.00 mg/100g for zinc, calcium, iron and magnesium, respectively. The vitamin composition of the drink ranged from 34.22 to 46.09 mg/100g; 1.87 to 3.09 mg/100g; 1.82 to 3.91 mg/100 g for vitamin A, vitamin B₁ and vitamin B₃ respectively. The flavonoid and phenolic contents of the drink ranged from 1.88 to 2.70 mg/g and 112.98 to 127.58 mg/g, respectively. The sensory evaluation of the drink shows that 50: 25: 25 tigernut-coconut-date milk is the most preferred for colour, taste and overall acceptability.

Keywords: Tiger nut, Date palm, Coconut milk, Vitamins, Phytochemicals

Introduction

The increase in production and consumption of carbonated drinks has posed a great dietary danger to many people since the drink lack essential nutrients and have contributed significantly to non-communicable diseases such as obesity, cardiovascular diseases, diabetes and micronutrient deficiency Eke-Ejiofor and Beleya (2018). Most soft drinks increase energy intake with little or no accompanying nutrition. It also affects the absorption of other nutrients such as calcium, therefore a reduction in soft drink consumption is recommended. In view of the aforementioned health risks associated with the consumption of soft drinks, the consumption of non-carbonated drinks especially from plant sources is now being promoted due to their nutritional value, flavour, aroma and colour (Ogbueke *et al.*, 2022).

Beverages from plant sources are nutritious and healthful drinks since they contain vitamins, minerals and antioxidants that play important role in the prevention of certain diseases. Tigernut has been demonstrated to be a rich source of quality oil and contains a moderate amount of protein. It is also an excellent source of some useful minerals such as

iron and calcium which are essential for body growth and development. Tigernut has also been reported to be used in the treatment of flatulence, indigestion, diarrhoea, dysentery, and excessive thirst. In addition, tigernut has been demonstrated to contain higher essential amino acids than those proposed in the protein standard for satisfying adult needs (Bosch *et al.*, 2005).

Coconut is a fruit rich in fibre (aids digestibility), iron, and other minerals. Coconut also serves as an excellent source of raw materials for the development of dairy-like products. It has many uses, most of which build up the immune and the body's defence system. It has no cholesterol and contains many vitamins, minerals and electrolytes, including potassium, calcium and chloride (Amarasiri and Dissanayake, 2006).

Date palm (*Phoenix dactylifera* L.) is a multipurpose tree providing, fibre, carbohydrates, minerals and vitamins besides having certain medicinal properties. As an ingredient to any recipe, dates provide the perfect natural alternative to added sugar. The blend of tiger nut, coconut and date drink could serve as a perfect replacement to reduce the diseases that are associated with the consumption of carbonated with high sugar content. The objective was to evaluate the mineral composition, phytochemical and sensory properties of non-alcoholic drinks from the blend of tiger nut, coconut and date fruits.

Materials and Method

Sample preparation

Sorted and cleaned tiger nut (1 kg) was blended with 2 L of distilled water and was pressed into a slurry with a muslin cloth to extract the milk. It was pasteurized at 72 °C for 5 min, homogenized, bottled and cooled at room temperature ($30 \pm 2^\circ\text{C}$) for two hours.

The sorted date fruits were cleaned and air dried. The fruits were cut into two equal parts to remove the seed and the pulp portion was homogenized in a blender. The extracted pulp was filtered by passing through a sterile muslin cloth into a clean transparent bowl.

Coconut milk was produced by blending the shredded pulp with an equal weight of warm distilled water (60°C) in a blender, filtered through a double-layered cheesecloth, and manually squeezed in a twisting motion to extract the milk. The extracted emulsion was pasteurized and stored in a refrigerator.

Blend formulation and preparation of drinks

The tigernut milk was blended with the coconut milk and date milk in varying proportions: 100:0:0, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 0:100:0. The blend was homogenised, bottled and pasteurised at 80°C for 10 min in a thermostatically controlled water bath with agitator, cooled to room temperature (27°C) and finally stored in a refrigerator at 5°C .

Determination of vitamin and mineral contents

Vitamin A, Vitamin B₁ (Thiamine) and Vitamin B₃ of the sample were all carried out according to the method described by AOAC (2005). Zinc, calcium, iron and magnesium contents of the sample were carried out following the method described by AOAC (2005).

Determinations of phytochemical composition

Total flavonoid and total phenol were determined using the method of Roesler *et al.* (2006).

Sensory Evaluation

The preference test was adopted to carry out the sensory evaluation. The samples were served to 50 semi-trained panellists made up of a population of staff and students of Ladok Akintola University of Technology, who are regular consumers of non-alcoholic drinks and juices. A 9-point hedonic scale was designed to measure the degree of preference of the samples.

Statistical Analysis

Data obtained from various analysis were subjected to analysis of variance (ANOVA) and the means were separated with the use of Duncan's multiple range test to detect a significant difference ($p < 0.05$) among the sample values using the Statistical Package for the Social Science (SPSS).

RESULTS AND DISCUSSION

Mineral and Vitamin Composition of Drink from Blends of Tigernut, Date and Coconut Milk

The result of mineral and vitamin compositions of the drink from blends of tigernut, coconut and dates palm milk is shown in Table 1. The zinc content of the drinks ranged from 59.10 to 75.30 mg/100 g with a drink with 100% coconut milk having the lowest zinc value while 100% tigernut drink had the highest value. There is no significant difference ($P > 0.05$) between the 80:10:10 tigernut-coconut-date milk and 50:25:25 tigernut-coconut-date milk. Zinc deficiency can result in growth retardation, infertility and alopecia. Zn has been known for antioxidant activities as well as protection against rapid ageing in humans (Sung, 2018). Consumption of the developed drink can reduce zinc deficiency problems. The calcium content of the drinks ranged from 65.33 to 92.08 mg/100g with sample 70:15:15 tigernut-coconut-date milk having the lowest calcium value while 100% coconut drink had the highest value. The calcium content of the drinks varies with an increase in coconut milk. There is no significant difference ($P > 0.05$) between the samples except 80:10:10 tigernut-coconut-date milk.

The iron content of the drinks ranged from 77.82 to 92.03 mg/100g with drink from 100% coconut milk having the lowest phosphorus value while 90: 5: 5 tigernut-coconut-date milk had the highest value. The high iron content in the drink could be due to the high iron content in tigernut and coconut, which can help to prevent iron deficiency anaemia (Omotosho and Odeyemi, 2012). The magnesium content of the drinks ranged from 7.46 to 23.00 mg/100g with drink from 100% coconut milk having the lowest magnesium value while 90:5:5 tigernut-coconut-date milk had the highest value. The magnesium content of the drinks varies with an increase in coconut-date milk. There is no significant difference ($p \geq 0.05$) between the 60:20:20 tigernut-coconut-date milk and 70:15:15 tigernut-coconut-date milk. The blend of coconut and tiger nut gave an array of mineral elements lacking in most carbonated drinks.

The vitamin A content of the drinks ranged from 34.22 to 46.09 mg/100g with drink from 90: 5: 5 tigernut-coconut-date milk having the lowest vitamin A value while 100% tigernut drink had the highest value. The values obtained agreed with the values (2.42 to 6.01 mg/100g) reported by Okafor and Ugwu (2014) for drink produced with African breadfruit,

cashew nut and coconut blends. There is no significant difference ($P \geq 0.05$) between the 60:20:20 tigernut-coconut-date milk and 50:25:25 tigernut-coconut-date milk.

The vitamin B₂ content of the drinks ranged from 0.25 to 0.39 mg/100 g with a drink from 100% coconut milk having the lowest vitamin B₂ value while drink from 100% tigernut milk had the highest value. The vitamin B₂ content of the drinks varies with an increase in coconut-date milk. The values obtained are within the recommended daily intake of 0.3 to 1.6 mg (Belitz *et al.*, 2009). There is no significant difference ($P > 0.05$) between the 60:20:20 tigernut-coconut-date milk, 70:15:15 tigernut-coconut-date milk and 80:10:10 tigernut-coconut-date milk.

The vitamin B₃ content of the drinks ranged from 1.82 to 3.91 mg/100 g with drink from 100% coconut milk having the lowest vitamin B₃ value while drink from 100% tigernut milk had the highest value. The values are much higher than the 0.157 to 0.477 mg/100 g reported by Okafor and Ugwu (2014) for drink produced with African breadfruit, cashew nut and coconut blends. There is no significant difference ($P \geq 0.05$) between the 60:20:20 tigernut-coconut-date milk, 70:15:15 tigernut-coconut-date milk and 50:25:25 tigernut-coconut-date milk.

Table 1. Minerals and Vitamins Composition of Drink from Blend of Tigernut, Date and Coconut Milk

Sample	Zinc (mg/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)	Magnesium (mg/100 g)	Vitamin A (mg/100 g)	Vitamin B ₁ (mg/100 g)	Vitamin B ₃ (mg/100 g)
A	75.30±0.18 ^c	85.16±0.89 ^b	85.53±0.14 ^d	11.20±0.21 ^b _c	46.09±0.99 ^c	2.51±0.06 ^c	3.91±0.05 ^c
B	59.10±0.66 ^a	92.08±0.70 ^c	77.82±0.34 ^a	7.46±0.39 ^a	39.75±0.15 ^d	1.87±0.04 ^a	1.82±0.04 ^a
C	80.13±0.44 ^f	65.33±2.57 ^a	92.03±0.14 ^f	23.00±0.21 ^d	34.22±0.08 ^a	1.96±0.02 ^a	1.97±0.01 ^b
D	69.61±0.61 ^d	90.52±1.47 ^c	90.52±0.47 ^c	11.00±0.21 ^b _c	35.15±0.11 ^b	2.14±0.06 ^b	2.19±0.07 ^c
E	65.63±0.14 ^b	84.98±0.89 ^b	81.15±0.42 ^b	11.59±0.37 ^c	35.53±0.07 ^b	2.22±0.08 ^b	2.31±0.03 ^d
F	67.52±0.01 ^c	86.30±0.59 ^b	81.10±0.25 ^b	11.55±0.17 ^c	36.47±0.06 ^c	2.21±0.02 ^b	2.31±0.04 ^d
G	68.84±0.67 ^d	87.09±0.01 ^b	82.39±0.08 ^c	10.59±0.06 ^b	36.87±0.08 ^c	3.09±0.10 ^d	2.35±0.05 ^d

Means within the same column with different superscripts are significantly different ($p < 0.05$)
A=100% Tigernut Drink; B=100% Coconut Drink; C=Drink from 90% Tigernut, 5% Coconut and 5% Date

D=Drink from 80% Tigernut, 10% Coconut and 10% Date; E=Drink from 70% Tigernut, 15% Coconut and 15% Date; F= Drink from 60% Tigernut, 20% Coconut and 20% Date; G= Drink from 50% Tigernut, 25% Coconut and 25% Date

Phytochemical Composition of Drink from Blends of Tigernut, Date and Coconut Milk

The phytochemical composition of the drink from the blend of tigernut, coconut and dates palm milk is shown in Table 2. The flavonoid content of the drinks ranged from 1.88 to 2.70 mg/g with a drink with 100% coconut milk having the lowest flavonoid value while 100% tigernut drink had the highest value. The presence of flavonoids in this study agrees with some reports that date palm contains some type of phenols, flavonoids and glycosides and that the concentration of these phytochemicals decreases with the advancing stage of fruit maturity. There is no significant difference ($P \geq 0.05$) between the 100% coconut-date milk and 90: 5: 5 tigernut-coconut-date milk.

The phenolic content of the drinks ranged from 112.98 to 127.58 mg/g with a drink with 100% coconut milk having the lowest phenolic value while 100% tigernut drink had the highest value. The phenolic content of the drinks varies with an increase in coconut-date milk. Studies have shown that they possess antimicrobial, anticancer and antioxidant properties. Their action is associated with their ability to form complex with extracellular and soluble proteins, and with bacterial cell walls (Mogana *et al.*, 2020). There is no significant difference ($P \geq 0.05$) between the 80:10:10 tigernut-coconut-date milk and 50: 25: 25 tigernut-coconut-date milk.

The estrogens content of the drinks ranged from 0.00 to 28.95 mg/g with a drink with 100% coconut milk having the lowest estrogens value while 100% tigernut drink had the highest value. The estrogen content of the drinks varies with an increase in coconut-date milk. There is a significant difference ($p < 0.05$) between samples.

Sensory Evaluation of Drinks from Blends of Tigernuts, Date and Coconut Milk

The sensory evaluation of the drink is shown in Table 2. The statistical analysis revealed that there were significant differences ($p < 0.05$) among the drinks samples in the sensory attributes observed. Drink from 50: 25: 25% tigernut-coconut-date milk had the highest score (7.20), while 100% tigernut milk had the lowest score (6.28) for colour. Also, the taste, texture and overall acceptability show that sample from 50: 25: 25 tiger n nut-coconut-date milk is the most preferred, this is as a result of the mixed taste of tigernut, coconut and date but the drink produced from 60:20:20 tiger nut-coconut-date milk and 70:15:15 tigernut-coconut-date milk can be a good choice because of the improvement in the nutritional content. It has been observed that the quality or integrity of a particular food sample can be determined by evaluating its sensory characteristic.

Table 2: Phytochemical Composition and Sensory Evaluation of Drink from Blends of Tigernut, Date and Coconut Milk

Sample	Flavonoid (mg/g)	Phenolic (mg/g)	Estrogens (mg/g)	Colour	Texture	Taste	Overall Acceptability
A	2.70±0.04 ^d	127.58±0.33 ^f	28.95±0.23 ^g	6.28±0.67 ^a	6.30±0.89 ^a	6.06±0.93 ^a	6.28±0.95 ^a
B	1.88±0.02 ^a	112.98±0.18 ^a	0.00±0.00 ^a	6.60±0.88 ^b	6.52±0.084 ^a b	6.38±124 ^a	6.44±0.99 ^a
C	1.94±0.02 ^a	116.46±0.16 ^b	15.71±0.03 ^b	7.00±0.81 ^c	6.84±0.84 ^{bc}	7.02±0.82 ^b	7.10±0.84 ^b
D	2.15±0.01 ^b	118.51±0.09 ^d	17.52±0.04 ^d	7.06±0.68 ^c	7.14±0.78 ^{cd}	7.36±114 ^{bc}	7.50±1.50 ^c
E	2.31±0.03 ^c	119.36±0.14 ^e	19.29±0.11 ^f	7.20±0.83 ^c	7.38±0.09 ^d	7.44±101 ^c	7.52±0.71 ^c
F	2.25±0.09 ^b c	117.40 ±0.11 c	18.45±0.04 ^e	7.08±0.83 ^c	7.38±0.09 ^d	7.50±0.89 ^c	7.56±0.84 ^c
G	2.30±0.01 ^c	118.20 ±0.01 d	16.42±0.01 ^c	7.20±0.95 ^c	7.38±0.09 ^d	7.58±0.88 ^c	7.78±1.00 ^c

Means within the same column with different superscripts are significantly different ($p < 0.05$)
A=100% Tigernut Drink; B=100% Coconut Drink; C=Drink from 90% Tigernut, 5% Coconut and 5% Date
D=Drink from 80% Tigernut, 10% Coconut and 10% Date; E=Drink from 70% Tigernut, 15% Coconut and 15% Date; F= Drink from 60% Tigernut, 20% Coconut and 20% Date;
G= Drink from 50% Tigernut, 25% Coconut and 25% Date

Conclusion: The developed drink is a good source of minerals, vitamins and phytochemicals with antioxidative potential. The sensory evaluation of the drink shows that the 50:25:25 tigernut-coconut-date milk is the most preferred for colour, taste, texture and overall acceptability. Blending tiger nut milk, coconut, and date fruits increased the acceptability of the drink. Therefore, consumption of the drink is recommended to lower the risk of developing non-communicable diseases and improve the industrial utilization of these crops.

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PROXIMATE AND PHYTOCHEMICAL COMPOSITIONS OF A FUNCTIONAL BEVERAGE PRODUCED FROM DATE SEED (*PHOENIX DACTYLIFERA L.*) AND MORINGA (*MORINGA OLEIFERA*) BLENDS

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ABSTRACT

Beverages plays an important role in the diets of people, the demand for the creation of functional food products, including beverages, as well as for the usage of isolated ingredients and supplements, has significantly increased, therefore the aim of the study is to develop a functional beverage with high nutritional value to meet the nutrient requirement of everyone. A coffee-like analogue was produced from date and moringa seed blends by drying, roasting, and grinding them in a similar way to coffee beans, to produce caffeine-free beverage. The ratio of roasted date palm seed to roasted moringa seed in the functional beverage was varied at 90%:10%, 80%:20%, 70%:30%, 60%:40%, 50%:50% and 100% roasted date palm seed as the control. The protein content, fat, total ash, crude fibre and carbohydrate also increased as the quantity of roasted moringa seed increased and as roasted date palm seed decreased. The total phenol, alkaloids and flavonoids ranged between 1.120 and 5.513 mg/g, 4.143 and 7.850 mg/g, 5.150 and 6.130 mg/g respectively. The ratio of raw materials (date palm seed and moringa seeds) in the functional beverage affected the proximate and phytochemical composition of the beverage.

Keywords: Functional beverage, Phytochemical, Coffee-like analogue

INTRODUCTION

The functional beverage industry sub-sector of the non-alcoholic beverage is at the front burner because of rising medical costs and market competitiveness to produce distinctive and convenient drinks (Alhussein, 2009). Demand for the creation of functional food products, including beverages, as well as for the usage of isolated ingredients and supplements, has significantly increased. Functional beverages are a relatively recent idea in Western culture, with its primary focus on the addition of ingredients meant to have positive health effects. Functional beverages are considered as fluids (and associated products) that can deliver functional benefits when consumed (Naumovskiet al., 2020). Greater demand for

healthy nutritious drinks, generally known as functional beverages, due to health concerns has led to the need to develop new beverages. *Moringaoleifera* belonging to the Moringaceae family, is said to provide more vitamin C than oranges, more vitamin A, more calcium than milk, more protein than yoghurt, more potassium than banana and more iron than spinach (AOAC,2005). *Moringaoleifera*, which is been considered the most nutrient-rich plant on earth, has long been known for its extensive therapeutic benefits. All over the continent of Africa, the plant's many parts are utilized for a variety of horticultural, medical, dietary, and phytochemical uses. A promising substitute for dietary supplements is *Moringa oleifera* seeds. It is known that *Moringa oleifera* seed flour, which is used to fortify wheat flour in the making of bread, biscuits, and cookies, and seed extract, which is used to thicken milk yoghurt, both enhance the nutritional and rheological characteristics of food. (Gautier *et al.*, 2022). Dates, *Phoenix dactylifera* L., an important member of the family Palmacea from the date palm tree, is composed of a fleshy pericarp and seed that constitutes between 10% and 15% of the date fruit's weight, depending on the variety and quality (Mbahet *al.*, 2012). Date seeds have beneficial nutritional qualities. It has a lot of dietary fiber. About 80% of the dietary fiber in date seeds was found in the coarsely ground variety, whereas 71% was found in the finely ground kind. Certain conditions like obesity, diabetes, high cholesterol, and digestive complaints can benefit from it. Date seeds include a variety of phytochemicals, such as flavonoids, phenolic acids, sterols, and tocopherols. Hesperidin (17.27 mg/100g) is a significant flavonoid that lowers cancer risk, prevents atherosclerosis, and slows bone loss. Protocatechuic, hydroxybenzoic, coumaric, ferulic, and caffeic acids are phenolic acids. (Algarni, 2020). Compositional analysis revealed that seed comprises of 10.20% moisture, 1.18% ash, 10.36% protein, oil, and 72.59% carbohydrate. Three major components (carbohydrate, protein, and oil) are important for seed germination. A coffee-like beverage can made from date seeds by drying, roasting, and grinding them in a similar way to coffee beans, to produce caffeine-free coffee. Date palm seed is caffeine-free and high in vitamins, minerals, antioxidants, and polyphenols, making it a healthy coffee substitute. These antioxidants protect the body from oxidative stress and the diseases that come with it, such as cancer, heart disease, and inflammation (Pandey and Rizvi, 2009). *Moringa* seed on the other hand is rich in fibre which is good for the digestive system, it regulates blood sugar levels making it suitable for people with diabetics, a good source of iron and essential amino acids, improves sleep, reduce joint pain, lower cholesterol, rich in antioxidants that protects the body from oxidative changes, induce death of cancer cells and promotes healthy skin. Therefore, the aim of this study is to develop a functional beverage, (coffee-like) from date seed-moringa seed blend that will possess the characteristics of a good beverage and meet the nutritional requirement of everyone and to consequently evaluate the proximate and phytochemical composition of the beverage.

MATERIALS AND METHOD

Date palm fruit was purchased from Alaba-rago market, Okokomaiko, Lagos, Nigeria. The moringa seeds were purchased from Aradagun Market, Badagry, Lagos. Date palm fruit was manually separated from the flesh. The seeds were soaked in warm water at 50°C for 10 minutes to remove any adhering residuals, then it was dried at 50°C for 24 hours to remove excess water from the surface of the seeds. The date palm seeds, spread thinly on aluminium foil were placed on a stainless tray, and roasted in an already preheated AX60 digital PID temperature controller laboratory oven (Carbolite Gero, Germany) at 180°C for 10 minutes to simulate the commercial roasting conditions of coffee. All roasted date palm seeds were allowed to cool at room temperature and then milled into powder with the aid of locally fabricated pressure type hammer mill with food contact part made of stainless steel been powered by 5KW 3 phase motor. The *moringa* seeds were picked, washed and drained and then roasted at 100°C for 20 minutes in an oven, prior to cooling and dehulling. The dehulled seeds were winnowed to remove the hulls. The clean dehulled seeds were milled into fine flour 425 µm mesh. The roasted *Moringa* powder were stored in a Ziploc double zipper bags (17.7cm x 20.3cm) in a cool dry place until it was ready for use according to a modified method of (modified method of Mbahet *et al.*, 2012). The roasted date palm seed flour and moringa seed powder produced were mixed at different blend ratios: 100% roasted date seed powder (control), the other samples were mixed in ratios. 90%:10%, 80%:20%, 70%:30%, 60%:40%, and 50%:50% of roasted date palm seed and roasted moringa seed respectively, packaged in teabag (corn fibre tea PLA bag by Fuyang Bestop, Anhui, China) and infused in hot water at 100 °C to get a tea like brew. The proximate composition (moisture content, crude fat, total ash, crude fibre, crude protein and carbohydrates) and phytochemicals composition (total phenol mg/g, alkaloids mg/g, and flavonoids mg/g) study of the beverages were done using standard method (AOAC, 2005). Statistical analysis of data was carried out using ANOVA and SPSS version 15

RESULT AND DISCUSSION

Proximate Composition of Date-Moringa Seed Beverage

Table 1 is the results of the proximate composition of the beverage produced from blends of date palm seed and moringa seed flours. The moisture content ranged between 5.33% and 10.70%. Moisture content is a major factor in determining the keeping quality or integrity of foods especially during storage and distribution. Results show significant differences ($p \leq 0.05$) among the samples. The trend of the moisture content observed in this study indicated that the moisture content increased as the substitution with roasted date palm increased and the lower the moisture content the lower the water activity and hence the better the keeping quality of the flour during storage. The protein content ranged between 9.85% and 12.88%. Protein is needed as building blocks for the body, necessary for growth and for the repair of damaged tissues. It was observed that FML had the highest value for protein and this may be due to Moringa seed being a rich source of protein which is the major component of the seeds after lipids. The total ash is an indicator of the mineral content of food samples. The total ash ranged between 2.16 and 4.33%. The trend of the

result of the total ash may be due to the fact that both date palm and moringa seed are rich sources of minerals. Crude fibre is one of the essential components that are often used to develop enriched foods, it is considered an efficient protective agent for a wide variety of illnesses, including cardiovascular disease, colon cancer and constipation. The crude fibre ranged between 4.84 and 7.58%. The results obtained for the fat content ranged between (2.66 and 3.29%) with FML as the highest and WZC as the lowest. Carbohydrate content is an indicator of how much energy that can be obtained from the consumption of a particular food product. The value of the carbohydrate content range between 63.66 and 70.77%. FML had the highest carbohydrate content and WZC had the lowest carbohydrate content. The result implied that as substitution ratio of roasted moringa seed powder increases the carbohydrate content of the beverage also increased.

Phytochemical Content of Date-Moringa Seed Blend Beverage

Table 2 is the results of the phytochemical composition of the beverage produced from blends of date palm seed and moringa seed flours. From the result, the total phenol content of the date seed-moringa seed beverage ranged between 1.210 and 5.510 mg-/l. WZC had the least total phenol content while FML had the highest phenol content. The results show that the alkaloids and phenolic content decreased with an increase in the ratio of roasted date palm seed incorporated. This may be due to the fact that date palm is a rich source of phenolic contents responsible for the stability of beverages. The alkaloids and the flavonoids ranged between 4.144 and 7.580, 5.150 and 6.130 mg-/l respectively. FML 50% had the highest alkaloids and flavonoids content while WZC had the least alkaloids and flavonoids contents

Table 1: Proximate composition of beverage from date palm seed and moringa seed

Sample	Moisture (%)	Crude Fat (%)	Total Ash (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)
FML (50:50)	10.70±0.1 ^e	3.29±0.03 _d	4.34±0.12 _e	7.58±0.03 ^f	12.88±0.03 ^f	70.77±0.11 ^f
UTS (60:40)	9.36±0.06 ^d	3.20±0.03 _c	3.92±0.03 _d	6.61±0.03 ^e	11.64±0.03 ^e	69.80±0.03 ^e
OHQ (70:30)	9.17±0.10 ^d	3.18±0.02 _c	3.58±0.03 _c	6.37±0.04 ^d	11.31±0.05 ^d	69.07±0.05 ^d
YDK (80:20)	8.67±0.05 ^c	3.07±0.04 _b	3.48±0.03 _c	5.81±0.05 ^c	11.22±0.03 ^c	66.50±0.11 ^c
GZX (90:10)	8.24±0.24 ^b	3.03±0.04 _b	3.28±0.03 _b	5.25±0.03 ^b	10.19±0.06 ^b	65.98±0.09 ^b
WZC 1(100)	5.33±0.19 ^a	2.66±0.03 _a	2.16±0.06 _a	4.84±0.03 ^a	9.85±0.03 ^a	63.66±0.15 ^a

Data are mean values of triplicate determination ± standard deviation. Mean values with the same letter within the same column are not significantly difference (p > 0.05).

FML 50% roasted date palm seed: 50% roasted moringa seed

UTS 60% roasted date palm seed: 40% roasted moringa seed
OHQ 70% roasted date palm seed: 30% roasted moringa seed
YDK 80% roasted date palm seed: 20% roasted moringa seed
GZX 90% roasted date palm seed: 10% roasted moringa seed
WZC 100% Roasted date palm seed (Control)

Table 2: Physicochemical composition of beverage from date palm seed and moringa seed

Sample	Total Phenol mg/100g	Alkaloids mg/100g	Flavonoids mg/100g
FML (50:50)	5.513±2.838 ^c	7.850±0.030 ^f	6.130±0.030 ^f
UTS (60:40)	4.743±0.086 ^c	7.130±0.046 ^c	5.903±0.015 ^e
OHQ (70:30)	3.437±0.025 ^{bc}	6.750±0.020 ^d	5.653±0.040 ^d
YDK (80:20)	2.533±0.021 ^{ab}	5.917±0.025 ^c	5.440±0.046 ^c
GZX (90:10)	1.843±0.040 ^{ab}	5.340±0.072 ^b	5.283±0.025 ^b
WZC 1(100)	1.210±0.050 ^a	4.143±0.042 ^a	5.150±0.026 ^a

Data are mean values of triplicate determination ± standard deviation. Mean values with the same letter within the same column are not significantly difference ($p > 0.05$).

WZC 100% Roasted date palm seed (Control)
GZX 90% roasted date palm seed: 10% roasted moringa seed
YDK 80% roasted date palm seed: 20% roasted moringa seed
OHQ 70% roasted date palm seed: 30% roasted moringa seed
UTS 60% roasted date palm seed: 40% roasted moringa seed
FML 50% roasted date palm seed: 50% roasted moringa seed

CONCLUSION

The ratio of raw materials in developing a functional beverage developed from date palm seed and moringaseedblendshad an effect on the nutritional content (proximate) and phytochemical composition of the coffee-like beverage.

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INFLUENCE OF MORINGA SEED FLOUR SUPPLEMENTATION ON THE PASTING PROPERTIES OF SWEET POTATO-BASED TAPIOCA GRITS

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Abstract

This study evaluated the influence of moringa seed flour (MSF) inclusion on the pasting properties of sweet potato-based tapioca grits. The MSF (2-10%) was properly blended with the sweet potato starch (SPS) (90-98%), using the ratios derived from the Central Composite Rotatable Design of the Design-Expert Software. The blends of SPS and the MSF, 100%SPS, and 100% cassava starch (CS) were toasted separately for 20 min at between 120°C-150°C, after which their pasting properties were determined using a standard method. The results showed that the pasting properties of the CS tapioca were significantly ($p < 0.05$) higher than that of the SPS tapioca except in the peak and breakdown viscosities, where the SPS tapioca was significantly higher. The addition of the MSF increased the peak viscosity of the SPS tapioca from 333 RVU to 426 RVU in 98%SPS:2%MSF and reduced it to 202 RVU in 98%SPS:10%MSF. Conversely, the breakdown viscosity of the SPS tapioca reduced generally with the inclusion of the MSF from 171 RVU to 29 RVU in the 98%SPS:10%MSF. Also, there was a general increase in the trough, final, and setback (except 98%SPS:10%MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF. Therefore, the addition of MSF in the production of the SPS tapioca grits increased most of the pasting properties, which may allow consumers to choose based on the level of viscosity preferred. However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence, the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

Keywords: Sweet potato starch tapioca, moringa seed flour, cassava starch, pasting properties,

Introduction

Sweet potato has become a research focus due to its versatility and adaptability to variation in climatic conditions. Its versatility ranges from cooking, roasting, confectionaries, flour, crisps, animal feed, starch, and sweet potato beverages to pounding (Egeonu, 2004). But there is presently little or no information on the use of sweet potato starch for tapioca production. Since cassava and sweet potato are traditional staples known to be particularly attractive to low-income people not only because of their nutritive and caloric values and contribution to livelihood systems but also their adaptability to a wide range of growing conditions and low

susceptibility to drought (Egeonu, 2004), the possibilities of producing cassava known product (tapioca) from sweet potato may be feasible. However, products developed from root and tubers are deficient in protein, micronutrients, and macronutrients; hence, the need for supplementation with moringa seeds in the form of flour. It is envisaged that the supplementation of tapioca grits produced from sweet potato starch with moringa seeds flour aside from being nutritious may affect the pasting properties, which are very important in the viscosity of the product. Therefore, this study aimed to evaluate the influence of moringa seed flour (MSF) supplementation on the pasting properties of sweet potato-based tapioca grits.

Materials and Methods

Sample collection and preparation: The sweet potato tubers were bought from a Oja Oba market in Ilorin and processed into SPS using the modified method of Awoyale *et al.* (2019) and the moringa seed was processed into MSF using Oluwole *et al.* (2013) method.

Experimental design using Design Expert: The MSF was properly blended with the partially dewatered SPS of particular moisture content using the ratios from the Central Composite Rotatable Design of the Design-Expert Software (Version 6.0). The SPS ranged from 90-98%, and the MSF 2-10%, this gave 13 runs with 5 central points for reproducibility of the data generated. Each blends of the SPS and the MSF, 100% SPS and 100% cassava starch (CS) were separately toasted for 20 min at 120°C-150°C,

Determination of pasting properties: The pasting properties of the samples were determined using a Rapid Visco Analyzer (RVA) (Model RVA-4C, Newport Scientific, Warriewood, Australia) interfaced with a computer equipped with the Thermocline Software supplied by the same manufacturer (Adebowale *et al.*, 2008).

Statistical analysis: Statistical Package for Social Scientists (SPSS) software (version 21.0) was used for the analysis of variance (ANOVA) and the separation of the means (using Duncan's Multiple Range Test at $P < 0.05$),

Results and Discussion

The pasting properties of the tapioca grits are important in predicting the behaviour of the gruel during and after cooking since it would be reconstituted in hot water before consumption (Adebowale *et al.*, 2008). Table 1 showed the pasting properties of SPS tapioca grits and that of 100% CS. The mean values of the pasting properties of the tapioca grits are peak viscosity 330.46 RVU, trough viscosity 231.08 RVU, breakdown viscosity 94.74 RVU, final viscosity 337.86 RVU, setback viscosity 109.72, peak time 5.09 min and pasting temperature 76.72°C. All the pasting properties of the CS tapioca grits were significantly ($p < 0.05$) higher than that of the SPS except for the peak (332.88 RVU) and breakdown (170.84 RVU) viscosities, which were higher than that of the CS. There was a general increase in the trough, final, and setback (except 98% SPS:10% MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF.

The peak viscosity is the maximum viscosity, developed during or soon after the heating portion of the pasting test. It also indicates the viscous load likely to be encountered during mixing in the preparation of the tapioca grits into gruel (Adebawale *et al.*, 2008). This implied that SPS tapioca grits might be more viscous than the CS tapioca when prepared into a gruel for consumption because of its high peak viscosity. Similarly, tapioca grits produced from 98%PS: 2%MSF (426.17 RVU) may be more viscous compared to that produced from 98%SPS: 10%MSF (201.92 RVU). The peak viscosity reported for 100% CS and tiger-nut enriched tapioca grits by Adeoti *et al.* (2017) was lower compared to that of this study. On the contrary, the peak viscosity of 100% CS tapioca grits reported by Adebawale *et al.* (2008) and Otegbayo *et al.* (2013) was higher than that of this study. The peak viscosity of the CS tapioca grits was not significantly different ($p>0.05$) from that of 99.66%SPS: 6%MSF, 90%SPS:10%MSF, and 94%SPS:11.66%MSF.

During the holding period of a typical pasting test, the sample is subjected to a period of constant temperature (usually 95 °C) and mechanical shear stress. This further disrupts the starch granule, and amylose molecules generally leach out into the solution and align in the direction of the shear (Adebawale *et al.*, 2008). The period is called the trough viscosity. The trough viscosity measures the ability of the paste to withstand breakdown during cooling (Newport Scientific, 1998). This means that tapioca gruel prepared from CS may withstand breaking down during cooling compared to that of the SPS, due to its high trough viscosity. Similarly, tapioca gruel prepared from 94%SPS: 0.34%MSF (302.71 RVU) may withstand breakdown during cooling compared to that of 98%SPS: 10%MSF (173.34 RVU). The trough viscosity of all the tapioca grits in this study was higher than that reported by Otegbayo *et al.* (2013) for soy-flour enriched tapioca grits and tiger-nut enriched tapioca grits reported by Adeoti *et al.* (2017).

The breakdown viscosity reflects the ability of the sample to withstand shear stress and heat during cooking. The higher the breakdown viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking (Adebawale *et al.*, 2005). This implied that tapioca gruel from SPS (170.84 RVU) might not withstand heating and shear stress during cooking due to its high breakdown viscosity compared to that of CS with low breakdown viscosity (50.80 RVU). Similarly, the gruel produced from 98%SPS:10%MSF (28.59 RVU) tapioca grits may withstand heating and shear stress during cooking compared to that of 98%SPS: 2%MSF (164.17 RVU) tapioca grits. It is of interest to add that the breakdown viscosity of the CS tapioca grits is not significantly different ($p>0.05$) from that of 99.66%SPS:6%MSF, 90%SPS:10%MSF and 94%SPS:11.66%MSF.

Final viscosity is the most used parameter to determine a particular starch-based sample quality as it indicates the ability of the material to form a gel after cooking (Adebawale *et al.*, 2008). The low final viscosity observed for the SPS tapioca grits (228.08 RVU) compared to the peak viscosity indicates their low tendency to retrograde (Moorthy, 2002), which may not be the case for the CS tapioca grits (354.38 RVU) with higher final viscosity. Similarly, the high final viscosity observed in 94%SPS: 0.34%MSF tapioca grits (456.59 RVU) may lead to a

higher tendency of retrogradation of the gruel, compared to that of 98%SPS:10%MSF (229.42 RVU) with lower final viscosity. The final viscosity of the CS tapioca grits was not significantly different ($p>0.05$) from that of 94%SPS:6%MSF and 88.34%SPS:6%MSF. The final viscosity of tapioca grits from different cassava varieties and roasting methods reported by Adebowale *et al.* (2008) was within the range of values reported in this study.

The viscosity after cooling to 50°C represents the setback or viscosity of the cooked paste. It is a stage where retrogradation or re-ordering of starch molecules occurs. Lower setback viscosity during the cooling of the paste indicates greater resistance to retrogradation (Sanniet *al.*, 2004). This means that tapioca gruel prepared from the SPS tapioca grits (66.04 RVU) may resist retrogradation compared to that of CS tapioca grits (133.30 RVU). Also, tapioca gruel made from 98%SPS:10%MSF tapioca grits (56.09 RVU) may withstand retrogradation because of its low setback viscosity compared to that of 94%SPS:0.34%MSF (153.88 RVU) with higher setback viscosity. Similar setback viscosity to that of the CS tapioca grits was observed in those of 94%SPS:6%MSF, 98%SPS:2%MSF, and 90%SPS:2%MSF, since there was no significant difference ($p>0.05$) in their setback viscosities.

When starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size. Over a critical temperature, which is the characteristics of a particular starch, the starch undergoes an irreversible process known as gelatinization. When the temperature rises above the gelatinization temperature, the starch granules begin to swell, and viscosity increases on shearing. The temperature at the onset of this rise in viscosity is known as the pasting temperature (Adebowale *et al.*, 2008). The pasting temperature is also a measure of the minimum temperature required to cook a given food sample, which may have implications for the stability of other components in a formula and indicate energy costs (Newport Scientific, 1998). The temperature required to cook the SPS tapioca grits (57.40°C) into gruel was lower compared to that of the CS tapioca grits (77.85°C). Besides, the temperature required to cook the SPS-MSF tapioca grits into gruel was higher at 94%SPS:6%MSF (82.40°C) and lower than that of 90%SPS:10%MSF (59.45°C). The pasting temperature of tapioca grits from different cassava varieties and roasting methods reported by Adebowale *et al.* (2008) and the soy-flour enriched tapioca grits reported by Otegbayo *et al.* (2013) were within the range of values of the present study, though the pasting temperature of the CS tapioca grits of this study was higher. Most of the values reported for the pasting temperature of tiger-nut enriched tapioca grits and that of the 100% CS reported by Adeoti *et al.* (2017) was higher compared to that of this study. The differences in the pasting temperature might be attributed to the varieties and different methods of the partial gelatinization of starch granules during roasting (Adebowale *et al.*, 2008). However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence, the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

Conclusion

The pasting properties of the CS tapioca were significantly higher than that of the SPS tapioca except in the peak and breakdown viscosities, where the SPS tapioca was significantly higher. The addition of the MSF increased the peak viscosity of the SPS tapioca in 98%SPS:2%MSF and reduced it in 98%SPS:10%MSF. Conversely, the breakdown viscosity of the SPS tapioca reduced generally with the inclusion of the MSF from in the 98%SPS:10%MSF. Also, there was a general increase in the trough, final, and setback (except 98%SPS:10%MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF. Therefore, the addition of MSF in the production of the SPS tapioca grits increased most of the pasting properties, which may allow consumers to choose based on the level of viscosity preferred. However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence, the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

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Table 1. Pasting properties of sweet potato-based tapioca grits and that of cassava starch

Tapioca samples	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min.)	Pasting Temperature (°C)
98%SPS:10%MSF	201.92±0.35e	173.34±0.94h	28.59±0.59g	229.42±0.71f	56.09±0.23f	5.90±0.04a	81.53±0.04a
90%SPS:2%MSF	407.38±1.12a	271.08±2.12b	136.29±1.00b	401.42±1.29b	130.34±0.83b	4.64±0.05de	79.43±0.53a
99.66%SPS:6%MSF	256.88±3.01d	204.09±0.59g	52.79±3.59f	281.21±3.71e	77.13±4.31e	5.44±0.05b	81.10±0.49a
88.34%SPS:6%MSF	323.21±4.42c	234.50±2.94e	88.71±1.47de	343.54±4.54c	109.05±1.59cd	5.00±0.00c	79.80±0.07a
94%SPS:0.34%MSF	417.63±2.54a	302.71±1.71a	114.92±0.83c	456.59±2.35a	153.88±0.64a	4.77±0.05cd	78.63±0.67a
98%SPS:2%MSF	426.17±0.71a	262.00±1.06c	164.17±1.77a	384.13±7.36b	122.13±8.42bc	4.44±0.05e	78.20±0.00a
94%SPS:6%MSF	355.08±11.80b	248.09±3.78d	94.80±2.58d	355.18±16.18c	117.60±11.16bc	5.39±0.20b	82.40±3.30a
90%SPS:10%MSF	270.21±3.01d	200.34±1.89g	69.88±4.89ef	312.17±5.66d	111.84±7.54cd	4.87±0.00cd	59.45±4.38b
94%SPS:11.66%MSF	273.38±3.36d	203.17±0.47g	70.21±2.89ef	301.17±5.89de	98.00±5.42d	5.07±0.09c	65.48±21.53b
Sweet potato starch	332.88±40.13bc	162.04±0.06i	170.84±40.18a	228.08±3.89f	66.04±3.83ef	4.34±0.19e	57.40±9.69b
Cassava starch	271.88±1.94d	221.08±3.18f	50.80±5.13f	354.38±4.42c	133.30±1.24b	5.00±0.10c	77.85±0.64a
Mean	330.46	231.65	94.74	337.86	109.72	5.09	76.72
p level	***	***	***	***	***	***	**

SPS-Sweet potato starch; MSF-Moringa seed flour; ***p<0.001; **p<0.01

Means with the same letters in the same column are not significantly different (p>0.05)

CHEMICAL COMPOSITION OF OYSTER MUSHROOM (*Pleurotus pulmonarius*) CULTIVATED ON DIFFERENT AGRICULTURAL WASTE

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Abstract

The chemical composition of *Pleurotus pulmonarius* mushroom cultivated on different agricultural waste materials was evaluated. The mushroom was cultivated on sawdust, corncobs, cassava peel and sugarcane bagasse and the samples were denoted with SDM, CCM, CPM and SBM, respectively. The different substrates influenced the chemical composition of the cultivated mushrooms. The highest protein and fat content were recorded in sample CCM and CPM at 35.69% and 3.44% respectively. Sample SBM had the highest crude fibre and carbohydrate content of 13.87% and 41.67%, respectively. The highest ash content was recorded in sample CCM (12.02%). The result for the mineral composition of the samples showed that potassium and selenium contents had no significant difference ($p > 0.05$) among all samples except for samples SDM and CCM. Copper and magnesium contents showed significant difference ($p < 0.05$) in sample SBM. Similarly, iron and calcium contents differed significantly ($p < 0.05$) across all the samples. The sodium content significantly differed ($p < 0.05$) in sample CPM. Samples SDM and CPM differed significantly ($p < 0.05$) from samples CCM and SBM in phosphorus. Samples SDM and CCM significantly differed ($p < 0.05$) from samples CPM and SPM in Zinc. The cultivation of edible mushrooms on cheap and readily available agricultural waste materials will not only reduce problems of agro-waste disposal but could also help produce nutritious and safe mushrooms thereby reducing the overgrowing problem of protein-energy malnutrition in developing countries.

Keywords: *Pleurotus pulmonarius*, Agro-waste, Mineral composition, Proximate composition

Introduction

Mushroom is the fleshy, spore bearing fruiting body of a fungus. Mushrooms are saprophytes and include members of the Basidiomycota and some members of the Ascomycota. Oyster mushrooms are valuable healthy food, that are low in calories, high in proteins, chitin, fiber and vitamins such as vitamin C, D the B-complex vitamins and minerals (Lee *et al.*, 2018). Mushroom protein appears to be intermediate in nutritional qualities between meat and vegetable proteins (Singh, 2017). Oyster mushroom are found in clusters naturally during the raining season in the wild, they are also easily grown on different

lignocellulosic agricultural wastes such as banana leaves, cereal straw, paper wastes, sawdust, rice husk and straw, and sugarcane residues. However, the yield and the quality of oyster mushroom depend on the chemical and nutritional content of substrates (Bhattacharjya *et al.*, 2015). The oyster mushroom (*Pleurotus* species) is the most easily and artificially cultivated and the cultivation has been regarded as the most profitably and environmentally friendly method of recycling agricultural waste which often cause environmental problems with a zero emission.

The interest of oyster mushroom is increasing largely due to its taste, nutrient, and medicinal properties are not often attacked by diseases and pests. Although, several research works had been conducted on the use of different substrates for cultivation of mushroom (Bhattacharjya *et al.*, 2015; Kinge *et al.*, 2016), however, there exist variations in their nutritional composition with different substrates. Most literature focuses more on the yield and there is dearth of information on the proximate and mineral composition of mushroom (*P. pulmonarius*) cultivated on sawdust, cassava peel, sugarcane bagasse and corncob which constitute environmental waste in Bida, Niger State. It is opined that this research could give valuable nutritional information on the mushroom (*P. pulmonarius*) as well as encourage mushroom farming in household or commercial basis which will hitherto increase consumption and more participation in cultivation of the mushroom and could help address malnutrition in the rural area and reduce food scarcity in the society.

Materials and Methods

Materials

Pleurotus pulmonarius spawns were purchased from LTC Farms Oshobgo, Osun State. The agro-wastes used in this study were sawdust, corn cob cassava peels and sugar bagasse. Sawdust was collected from the local sawmill in Bida, corncob and cassava peels were collected from the local processors. The sugarcane bagasse also was obtained from the local sugarcane juice producer in Bida, Niger State Nigeria. These were then collected in jute bags and transported to the laboratory. All reagents used for this study were of analytical grade.

Preparation of substrates

Twenty kilograms each of the corncob, cassava peel and sugarcane bagasse were cleaned by removing the extraneous particles, followed by pulverization. Essentially, 20 kg each of the substrates was added calcium carbonate 1:32g (w/w) and then soaked in water in the ratio 1:2(w/v), heaped and covered to allow for fermentation process for 7 days, turned for every two days so as enabling the cellulosic breakdown by the effective microorganisms. The substrates were drained and 1kg of each substrate was weighed into 15x30cm of polyethylene bags and these were autoclaved at 121°C for 15 minutes at 15 psi and allowed to cool.

Mushroom cultivation and processing

The cultivation was carried out using the method described by Ariahuet *al.* (2009) with slight modification. After cooling, the substrates were inoculated with 20g each of *P. pulmonarius* spawn. The inoculated substrates were then transferred to a darkroom where the temperature and relative humidity were maintained between 25-27°C and 80-90% respectively with adequate ventilation. The inoculated bags were left for full colonization of the substrate by mycelia. Full ramification was achieved in 55 days. The bags were watered and fruiting bodies of the mushroom (*P. pulmonarius*) developed were harvested. Mushrooms were cleaned and then cut into slices, dried in an air draft oven (Gallenkamp, Cheshire, UK) at 45°C, until constant moisture content was obtained. The various dried mushroom samples were grinded using an electric grinder and sifted through 500µm screen to obtain mushroom (*P. pulmonarius*) fine powder from sawdust (SDM), corncob (CCM), cassava peel (CPM), and sugarcane bagasse (SBM). These samples were coded and placed in airtight containers and stored at room temperature.

Methods

Proximate analysis:

Moisture content, protein, fibre, fat and ash contents of mushroom samples were determined using the AOAC (2012) methods. Carbohydrate content was calculated by difference. The difference in value was taken as the percentage total carbohydrate content of the sample.

Mineral analysis:

Sodium and potassium were determined using flame photometer while the levels of calcium, zinc, phosphorus, magnesium, iron, selenium, copper and lead were determined using Atomic Absorption Spectrophotometer (Perkin-Elmer, Analyst A700) after digestion with concentrated nitric acid (AOAC, 2012).

Statistical analysis

The experimental results were expressed as mean $\pm$ standard deviation (SD) of three triplicates. Data obtained were analyzed using one way Analysis of variance (ANOVA) using Statistical Packages for Social Scientists (SPSS) version 18. The level of significance was set at 0.05 and means separated with Duncan's New Multiple Range Test (DNMRT).

Results and Discussion

Proximate composition of *P. pulmonarius* mushroom cultivated on different substrates

The proximate composition of the various mushroom (*P. pulmonarius*) flours from different substrates are presented in Table 1. The moisture content, protein, crude fibre content ranged between 6.52-7.31%, 24.23-32.76%, and 10.73-13.87%, respectively. While the ash and crude fat ranged from 8.13-12.02% and 2.01-3.44%, respectively. The variations in the proximate composition of the samples cultured on different substrates conformed to

previous studies reported by Bhattacharjya *et al.* (2015); Kingeet *et al.* (2016). The protein contents of mushroom depended on biological, chemical differences and the carbon nitrogen ratio of substrate therefore variations in values. The crude protein content of *P. pulmonarius* and crude fiber content are within the range of values of 25.1 to 29.5% and 5.1% to 16.7% as reported by Kingeet *et al.* (2016) for oyster mushrooms cultivated on corncobs and sawdust. Therefore, *P. pulmonarius* mushroom can be ranked as protein-rich food and also good source of fibre. This could be advantageous composite flour production.

The ash and fat content in this study are within the range 7.0 - 9.5% and 2.0% - 4.6% reported by Kingeet *et al.* (2016). A slightly lower ash value of 7.52% - 8.54% and higher fat content values 3.89 and 4.32% were reported by Okwulehie *et al.* (2014) for *P. pulmonarius* cultivated on sawdust and *Andropogon ganganus* straw. Low carbohydrate content ranging between 29.26-41.67% was recorded in all the samples. Mushrooms generally are low in carbohydrate because they are non-photosynthetic, therefore can be recommended in weight loss, diabetic and heart patients (Singh, 2017).

These variations in the chemical composition may be attributed to the differences in the substrate used for cultivation, since the growth performance and nutritional composition of oyster mushrooms depend on the composition of substrate on which they are cultivated (Khare *et al.*, 2010).

Table 1: Proximate composition of mushroom (*P. pulmonarius*) cultivated on different agricultural wastes

Parameters (%)	SDM	Mushroom flours CCM	CPM	SBM	Values are
Moisture	6.52 ^d ±0.10	7.31 ^a ±0.20	7.05 ^b ±0.10	6.98 ^c ±0.10	
Crude protein	33.24 ^b ±0.10	35.69 ^a ±0.15	32.76 ^c ±0.01	26.23 ^d ±0.02	
Crude fibre	10.73 ^d ±0.05	12.79 ^b ±0.10	11.23 ^c ±0.10	13.87 ^a ±0.10	
Ash	9.91 ^c ±0.10	12.02 ^a ±0.01	10.47 ^b ±0.20	8.13 ^d ±0.00	
Crude fat	2.01 ^d ±0.11	2.91 ^c ±0.10	3.44 ^a ±0.23	3.11 ^b ±0.15	
Carbohydrate	38.93 ^b ±2.33	29.26 ^d ±0.02	35.05 ^c ±0.35	41.67 ^a ±0.23	

Means ± Standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different (p<0.05).

SDM= Sawdust cultivated mushroom

CCM= Corncob cultivated mushroom

CPM= Cassava peel cultivated mushroom

SBM= Sugarcane bagasse cultivated mushroom

ND= Not detected

Mineral composition of *P. pulmonarius* mushroom cultivated on different substrates

The mineral composition of the various mushroom (*P. pulmonarius*) flours from different substrate are shown in table 2. The potassium content of samples ranged from 61.17-67.77mg/100g with sample SDM having the highest while the sodium ranged from 52.67-57.82mg/100g with sample CPM having the highest value. Mushrooms are high in

potassium and low in sodium, consumption of mushrooms can help decrease the risk of high blood pressure and cardiovascular disease. Similarly, sample CPM recorded the highest phosphorus content (147.94mg/100g) which showed no significances ($P>0.05$) from sample SDM. The highest amount of iron and calcium were observed in samples SBM and CCM with values ranging from 30.14-45.95mg/100g and 100.09-140.45mg/100g, respectively. The iron content in the samples agrees with Ogundele *et al.* (2014) who reported 4.14mg/kg iron content. The zinc content of the samples ranged from 2.72-3.35mg/100g with sample CCM recording the highest value. Samples SDM and CCM showed no significances ($p>0.05$). The copper and magnesium content of the samples ranged from 0.06-0.24mg/100g and 26.16-28.38mg/100g, respectively. The result for the magnesium agrees with the report of Agomuo *et al.* (2011). Selenium content of samples ranged from 0.04- 0.08mg/100g with sample SDM having the highest value. The values recorded were within the recommended daily intake of 0.06mg and did not exceed the upper intake level of 0.4mg daily of selenium. Sample SBW recorded the highest values for both minerals. There was no trace of lead in any of the mushroom samples. The difference in substrate used showed no significant difference with values obtained which indicate that the four substrates may contain nearly the same mineral content. The result of the current study disagrees with the findings of Ogundele *et al.* (2014) who reported high mineral content in *P. ostreatus* for potassium (885.06mg/kg), zinc (3.08mg/kg), magnesium (65.58mg/kg), and lower calcium (3.04mg/kg) contents cultivated on different sawdust substrates.

Table 2: Mineral composition of mushroom (*P. pulmonarius*) cultivated on different agricultural wastes

Parameters (mg/100g)	SDM	Mushroom flours CCM	CPM	SBM
Potassium	67.77 ^a ±0.58	61.71 ^b ±0.73	61.29 ^b ±0.30	61.17 ^b ±0.15
Sodium	54.53 ^b ±0.47	52.67 ^c ±0.67	57.82 ^a ±0.34	53.54 ^{bc} ±0.58
Phosphorus	147.89 ^a ±0.58	138.13 ^b ±0.99	147.94 ^a ±0.56	138.28 ^b ±0.24
Iron	40.04 ^b ±0.32	37.88 ^c ±0.59	30.14 ^d ±0.01	45.90 ^a ±0.73
Calcium	100.09 ^d ±0.23	140.45 ^a ±0.56	105.93 ^b ±0.57	102.28 ^c ±0.56
Zinc	3.32 ^a ±0.24	3.35 ^a ±0.18	2.72 ^b ±0.05	2.79 ^b ±0.08
Copper	0.06 ^b ±0.01	0.07 ^b ±0.00	0.06 ^b ±0.01	0.24 ^a ±0.01
Magnesium	27.09 ^b ±0.57	26.75 ^b ±0.42	26.16 ^b ±0.24	28.38 ^a ±0.59
Selenium	0.08 ^a ±0.01	0.04 ^b ±0.01	0.07 ^a ±0.01	0.07 ^a ±0.00
Lead	ND	ND	ND	ND

Values are Means ± Standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different ($p<0.05$).

SDM= Sawdust cultivated mushroom
CCM= Corncob cultivated mushroom
CPM= Cassava peel cultivated mushroom
SBM= Sugarcane bagasse cultivated mushroom
ND= Not detected

Conclusion

The study demonstrated that cultivation of edible *P. pulmonarius* mushroom on cheap and available agricultural waste materials greatly influenced the chemical composition of the samples. The proximate composition analysis revealed that the fruiting bodies harvested from corncob and sugarcane bagasse substrates hold tremendous promise of nutritious food source that is rich in protein and fibre and therefore recommended. The result for the mineral composition of the fruiting bodies also indicated an excellent source of vital minerals. Absence of lead in the entire mushroom cultivated indicates non-potential health risk for the consumers. Therefore, mushroom farmers should adopt the use of these agro-waste materials for cultivation in order to produce nutrient-dense and safe mushrooms for consumption. Thus, utilization of these agro-wastes; for the production of oyster mushrooms could be more economically and ecologically practical.

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COMPARATIVE EVALUATION OF METHODS FOR THE PROCESSING OF MANGO FRUITS INFECTED WITH BLACKSPOT DISEASE

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Abstract

Effectiveness of processing on the quality of products obtained from varying degree of black spot disease infected mangoes was investigated. The incidence of the disease in Nigeria was surveyed before the production of juice and puree from (non-infected-HNM), superficially-infected (black spots on flesh without depressing inward-SBM) and deep flesh-penetrated black spot diseased mangoes (DPM). Physico-chemical and microbiological assessments were determined. The survey showed the incidence of the disease in South-West Nigeria (87%) was significantly higher ($p \leq 0.05$) than South-South region (35%). The moisture contents of the fruits were not significantly different ($p \geq 0.05$) and ranges between $84.66 \pm 0.26\%$ for HNM to $90.75 \pm 0.75\%$ for SBM. The pH differed significantly ($p \leq 0.05$) and range between 2.8 for HNM to 3.9 for DPM. Total bacteria counts significantly differed ($p \leq 0.05$), ranging from zero for juice black spot mango and puree from HNM to 4.67×10^4 cfu/g for DPM. Coliform counts negative for all samples while total fungal counts (TFC) ranged from zero (puree) to 3.5×10^4 cfu/g (fresh DPM). The study indicated processing can yield products of acceptable quality from black spot disease infected mango fruits. Hence, with the prevailing food insecurity plaguing the country, superficial black spot diseased mango fruits can be adapted for processing.

Key words: Black spot disease, Mango, Raw material, Food security, Processing methods

Introduction

Raw materials quality is a necessary factor of overall product quality in food processing. This fact often informs manufacturer's choice of premium quality of raw materials for processing operations. But, there are times when uncontrollable occurrences lead to unavailability of such desired high quality ingredients. Producers are left with seeking affordable alternatives, one of which is to adjust processing techniques to adequately circumvent the defects, if the regular methods are ineffective; otherwise, the condition of 'garbage in, garbage out' would ensue. In other words, available raw materials in those particular instances, coupled with the drive towards assuring food security by minimizing wastages of 'edible' portions, may predispose a producer to utilize non-premium food commodities for food processing operations. Such instances may include agronomic diseases that affect fruits and harvest, scarcity of particular desired raw material, abundant harvest of a specific perishable food commodity and others. Consequently, the need to improvise upon and adapt processing

activities appropriately becomes necessary.

Meanwhile, mango (*Mangifera indica*) is a nutritious, sweet-tasting, juicy, abundantly available fruit commodity during glut season. Nigeria is said to be the tenth largest producer of mango in the world with an estimated output of about 800,000 metric tons annually (Obialo, 2022). With the exception of Benue state where mangoes are farmed as economic commodity, most of the mango fruits produced in other states of Nigeria are in subsistence quantity. Thus, other states of Nigeria often source large quantities of mango from Benue state (IBID). Excess mangoes are processed into juice, jam, puree, nectar, dried slices and bars (FAO, 2020). Mango is highly susceptible to various diseases and other agronomic challenges. One of such disease that affect mango is the black spot disease, which is an appearance of black coloration on few locations or throughout the flesh of mango fruits. This condition is of two types and are caused by two different classes of microorganisms: bacteria and fungi. The bacterial black spots disease (BBD) of mango has symptoms that look similar to that of fungal black spot disease (FBD) of mango. But, on closer inspection, the black spot symptom is distinct for each class of causative organisms. The FBD is regarded as a symptom of mango Anthracnose disease, which is termed as the most prevalent and economically important disease of mango worldwide (Zainab and Shinkafi, 2016). Regularly implicated organism of BBD of mango is *Xanthomonas* sp. *pvmangiferaeindicae* (Honger *et al.*, 2021), while causative organisms of FBD include fungi like *Colletotrichum gloeosporoides*, *C. acutatum*, *Glomerella cingulate* (Akem, 2006) and *Alternaria* sp. (Zainab and Shinkafi, 2016). These pathogens cause great economic losses by rendering mangoes worthless and unavailable, thereby impacting food security negatively.

Food security has been a nagging challenge in developing nations like Nigeria, despite great levels of agricultural food production. This can mainly be attributed to man-made factors of wastages and careless practices, and to an extent -natural factors like disease. Food wastage is deliberate discarding of edible food portions, while careless practices include avoidable spillage of edible food during production. This man-made cause of food insecurity led to an agenda of the United Nations to attain food loss reduction by half by the year 2030 (Omezzine *et al.*, 2019). In the case of mango, pest and disease attacks lead to destruction of mango fruits that renders them unfit for consumption. Such unfit mangoes are often discarded off, to further constitute environmental pollution. In either case, food processors are unable to access desired quality raw materials (like mango fruits) for their operations - thus resulting in either searching for alternative sources of fruits (which may be more expensive) or proceed with whatever is available while expending more resources to augment regular techniques so that the desired quality levels can be maintained.

Hence, this study was conducted to ascertain level of occurrence of black spot disease of mango in the harvest season of 2022 in Nigeria, and compare the effects of some usual processing methods on samples of healthy and diseased mango fruits. Specifically, a survey was conducted in the six regions of Nigeria to evaluate the incidence of the disease in Nigeria, and comparative assessment of some quality parameters was carried out on both healthy and diseased mango fruits, together with some products obtained from them -to determine the effectiveness of the processing methods.

Materials and Methods

Survey

A survey was conducted in the six geopolitical zones of Nigeria to ascertain the incidence and distribution of the black spot disease of mango in Nigeria. One State in each region of Nigeria was randomly selected for sampling. The main regional States surveyed are Abuja (North-Central), Kano (North-East), Zamfara (North-West), Lagos (South-West), Cross-River (South-South) and Anambra (South-East).

Sampling

Samples of mango fruits were obtained from Izommarket in Niger state and sorted into three categories of healthy (non-infected), superficially-infected (black spots on flesh without depressing inward) and deep flesh-penetrated black spot diseased mangoes. These were labelled HNM, SBM and DPM respectively. Thereafter, samples were drawn from the fresh mango categories for initial quality assessments.

Quality Parameters of Mango fruits and Products

Each category of samples was subjected to same conditions of handling and processing methods to obtain juice, jam and puree for comparative quality evaluations. The mango products were formulated according to FAO (2020) standards for mango juice, puree and jam. Samples of the mango products for each category, together with the fresh (unprocessed mango pulp) samples earlier drawn were analyzed for microbiological enumerations, moisture content (MC) and pH. Standard procedures of AOAC (2019) were adopted for MC while ATC pH meter model no. PH-009(1)A was used for pH measurement.

For microbiological enumerations, samples were cultured on nutrient agar plates for total bacteria count (TBC), MacConkey agar for total coliform count (TCC) and on Sabouraud dextrose agar plates for total fungi count (TFC). Bacteria cultured plates were incubated at 37°C for 24 hours for bacteria, and at room temperature of about 25°C for 7 days for fungi.

Results and Discussion

Survey

The incidence of black spot disease on mango fruits in the year 2022 (March-May) harvest season is illustrated in figure 1. From the samples examined in each region of Nigeria, the proportion of mango fruits with black spot symptom in South-West was significantly ($p \leq 0.05$) highest with 87%, followed by North-Central with 36%, while South-South region had the lowest proportion with 35%.

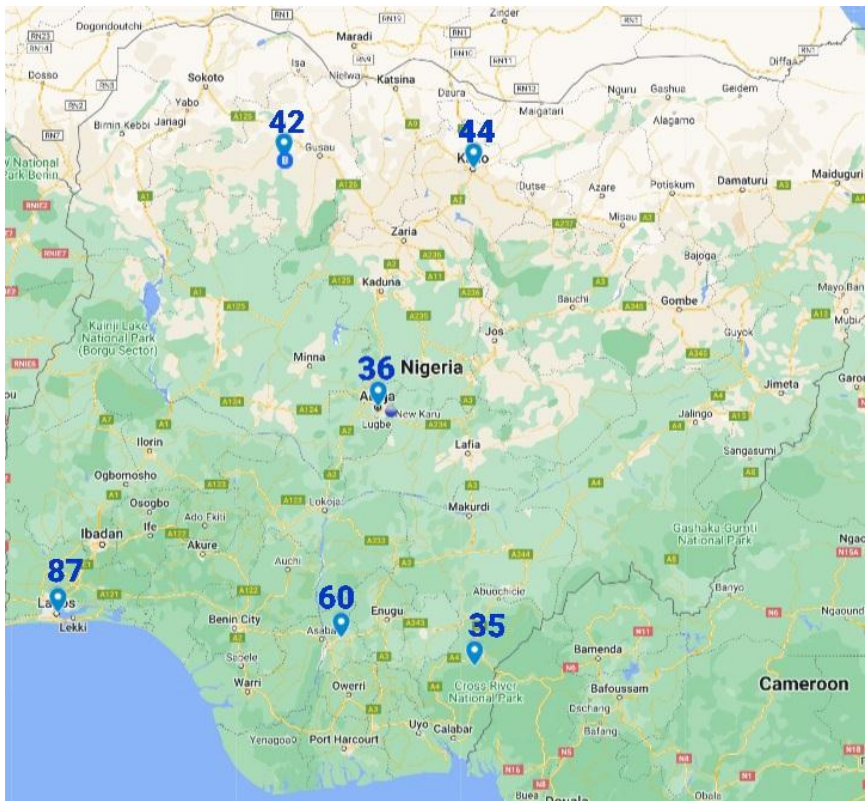


Figure1: Incidence of the black spot disease of mango in Nigeria (%)

Quality Parameters of Mango fruits and Products

The result of quality parameters of all samples is presented in Table 1. The moisture content of the mango fruits samples ranges from $84.66\pm0.26\%$ for penetrated black spot infected mango (DPM) fruits to $90.75\pm0.75\%$ for superficial black spot infected mango (SBM) fruits. The pH values significantly ($p\leq0.05$) ranged from high acid of 2.8 ± 0.52 for fresh healthy mango to moderate acid of 3.9 ± 0.20 for fresh penetrated black spot infected mangoes. The MC and pH parameters were not determined for the processed samples.

Table 2: Quality Parameters of Fresh and Processed Mango Samples

Samples	MC (%)	pH	Microbiological Enumerations (cfu/g)		
			TBC	TCC	TFC
Fresh HNM	86.03 ± 0.46^a	2.8 ± 0.52^a	1.18×10^{4a}		1.3×10^{4a}
Fresh SBM	90.75 ± 0.75^a	3.7 ± 0.21^b	1.07×10^{4a}		3.4×10^{4a}
Fresh DPM	84.66 ± 0.26^a	3.9 ± 0.20^b	4.67×10^{4a}		3.5×10^{4a}
Juice HNM	-	-	5×10^{1b}		5×10^{1b}
Juice SBM	-	-	00	2×10^{2c}	
Juice DPM	-	-	5×10^{1b}		3.5×10^{2c}
Puree HNM	-	-	000		
Puree SBM	-	-		5×10^{0b}	
Puree DPM	-	-	000		

Key: Means with different letters of superscript along a column are significantly different ($p \leq 0.05$) from one another. Values are recorded as means of triplicate measurements. HNM = Healthy Mango, SBM = Black-spot Mango, DPM = Deep Penetrated Black Mango.

Microbiological enumerations show result of total bacteria counts (TBC) significantly ($p \leq 0.05$) range from 0 for samples juice black spot mango (JSBM) and puree healthy mango (PHNM), 5×10^0 cfu/g for puree SBM, through 5×10^1 for juice healthy mango (JHNM) and juice deep penetrated black mango (JDPM), to 4.67×10^4 cfu/g for fresh DPM. The total coliform counts (TCC) result was nil for all cultured samples, while the total fungal counts (TFC) significantly ($p \leq 0.05$) ranged from nil for puree SBM, through 5×10^1 for juice HNM to 3.5×10^4 cfu/g for fresh DPM.

From the result of the survey for incidence of black spot disease of Mango, it can be seen that South-West had significantly ($p \leq 0.05$) highest incidence of the disease of black spot. This high incidence could be attributed to many factors. Firstly, the impact of a disease outbreak are often felt the most in Lagos state, as Lagos state is a densely populated hub of inter-state and international commercial activities. Secondly, the continuous rainfall and resulting high humidity of Lagos State makes it easily favourable to development of various types of microbial attacks, a view supported by the conclusion of a study in Taiwan whereby a positive correlation was established between these parameters (Ann *et al.*, 1994). Following the South-West is South-East that had significantly higher incidence level ($p \leq 0.05$) than the rest. The South-South region had surprisingly lowest incidence of mango black spot disease from the study, despite being a region of highest rainfall and humidity in Nigeria. The Northern Nigeria had comparatively lower incidence of mango black spot disease, with a combined average of 40.6%. This lower score could be as a result of lower rainfall and humidity pattern of these regions, while these parameters are considered as factors of the disease development (as stated earlier).

In mango processing operations, such high proportion of infected mango fruits ordinarily implies that about 4 out of 10 mangoes produced and/or sold in the Northern regions and as high as 8 out of 10 mango fruits produced and/or sold in the South-West (especially in Lagos state) cannot be utilized for value-added production, if good manufacturing practices (GMP) are to be complied with. Such fresh (but diseased) mango fruits are not expected to be consumed either. In other words, they would constitute a large stream of waste to further aggravate an already-saturated polluted environment; as well as increase food insecurity after great expended effort in agricultural production, a condition that United Nations SDG Agenda 2030 is fighting to overcome (Omezzine *et al.*, 2019). Thus, a simple way forward would be to examine the possibility of adapting processing techniques to adequately circumvent the challenge while maintaining acceptable safety quality standards. The second aim of this study addressed this.

The moisture content of all fresh sample were not significantly different from one another ($p \geq 0.05$), as they were all within the range often reported for fresh juicy mango fruits such

as in Bello *et al* (2016). The moisture content of a food can be regarded as the most important factor of shelf stability of the food, as high moisture subject such food like mango fruits to easy microbial attack and perishability. On the other hand, pH value of 2.8 for fresh healthy mango sample was significantly lower ($p \leq 0.05$) than those of the other two samples. Usually, the low pH of fruits was expected to confer a higher protection against common spoilage and pathogenic organisms in fruits. But this does not exclude acidophiles, which grow best at acidic pH range. The lower pH recorded from this study, as against common range of 3.9 for matured mango to 6.8 for fully ripe mango (Rooban *et al.*, 2016) could be due to the particular variety or forced ripening of mango fruits since the obtained values are usual for unripe mangoes.

The microbiological analysis result across all nine samples indicated significant differences in microbial counts between fresh samples and the processed samples. The processed samples were all significantly less contaminated than their fresh versions, with some samples exhibiting sterile results; as a consequence of the processing methods that involves heating (pasteurization) and addition of sugar. The microbial counts of all processed samples were within acceptable microbial limits of Gulf standard. For instance, the maximum regulatory limit for fruit juice are 1×10^4 cfu/g for total aerobic counts and 1×10^3 cfu/g for fungi (GSO, 2014), while the maximum enumerated value for juice from all categories of samples is 5×10^1 cfu/g for total count and 3.5×10^2 cfu/g for total fungi. The processing method for puree production yielded quality product that was mainly sterile, except for puree SBM that had a slight growth of 5 cfu/g that could easily be due to systematic contamination rather than the sample. Particularly notable is that both fresh and processed sample showed complete absence of coliform group of bacteria, which is indicator organism of sanitary condition against potential pathogens. Possibly, the high acid intrinsic environment of mango fruits inhibits growth of coliform group, which has optimal growth at pH around 6.8 to 7.5.

Conclusion

The result of this study provided some evidence that regular processing methods for mango are adequate to present products of acceptable quality standards of safety, if such processing techniques are appropriately carried out according to specified FAO processing method recommendations that were adopted in this study. Where necessary, though, processing techniques may be augmented with further control measures to improve the standards of final products. However, it is recommended that shelf-life studies should be conducted to ascertain the keeping quality of these mango products, as the whole essence of commercial food processing is present value-added products to retail customers in wholesome quality status.

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PROXIMATE COMPOSITION OF GERMINATED *FONIO* (*DIGITARIA IBURUA*) MUSHROOM (*PLEEUROTUS PULMONARIUS*) AND GINGER (*ZINGIBER OFFICINALE*) COMPOSITE FLOUR AND SENSORY PROPERTIES OF THE BISCUITS PRODUCED THEREOF

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Abstract

Biscuits were prepared from germinated *fonio*, mushroom and ginger flour blends. This study was carried out to evaluate the proximate composition of flour blends and sensory attributes of the biscuit. Composite flours were produced from germinated *fonio*, mushroom and ginger at varying proportions using I-optimal mixture design expert (version 10, Stat-Ease Inc., USA) to produce 17 flour blends giving the ingredients in the range of germinated *fonio* (78-94%), mushroom (4 -19 %) and ginger flour (1-5%). Proximate composition of the composite flours was evaluated using standard methods. The crude protein and fibre were 9.42-15.25% and 3.25-9.91 % respectively. The ash, fat and carbohydrate values within the composite flour were from 68.00-3.53 %, and 1.55-2.70 %, and 61.08-76.25% respectively. Biscuits prepared from sample O score (8.20, 8.25, 8.70, 8.5, 8.07, 8.00) base on appearance, colour, taste, aroma, crispiness and overall acceptability respectively were most accepted by the panelist. Therefore, based on the proximate composition and sensory evaluation, it is evident that biscuits high in protein and other nutritious properties can be produced from the composite flour and can be utilized industrially.

Keywords: *Fonio*, Mushroom, Ginger, Proximate, Sensory properties

1.0 Introduction

Biscuits, like the majority of ready-to-eat (RTE) snacks that are made with cereal, either alone or in combination with pulses, tubers, fruits, and vegetables. Biscuits are a popular bakery product that appeals to people of all ages because of their longer shelf life, better taste, and role as snacks (Jayatilakanet *al.*, 2015). The main ingredient in biscuit making, wheat, is low in vitamin A but high in protein, fiber, carbohydrate, and energy. But when wheat is milled and turned into flour, the bran that contains these nutrients is removed. Dependence on wheat for baking has been a significant issue in Nigeria. As a result, the resulting wheat flour and its products become deficient in these nutrients and their consumers experience problems with protein-energy malnutrition Ahure and Ejoha (2020). Increasing production costs, an increase in the price of baked goods, and a progressive decline in affordability have been caused by higher importation costs as a result of foreign exchange issues. While Nigeria's climate is not ideal for growing wheat, it is ideal for growing other cereal crops like acha and maize. Therefore, any attempt to replace wheat flour with any of the locally accessible grain flours will significantly cut the price of baked goods in Nigeria. *Fonio* (*Digitaria Iburua*), also known as acha, is a naturally gluten-free African cereal suitable for use in the diet of celiac patients and it is one of the oldest cereals characterized with a pleasant small seeds. Acha is noted for its high pentosan, an attribute recognized for

good baking operation (Ayo *et al.* 2016). The grain is uniquely rich in methionine and cystine, and evokes low sugar on consumption. Ayo *et al.* (2007) reported fortified *fonio* and wheat flour with soybean to increase its protein content. Edible mushrooms are a good source of high-quality protein. Lysine, which is scarce in cereal but abundant in mushrooms, has a number of antioxidants and is advised as a healthy food supplement for people with diabetes and cardiovascular disease (Fernandes *et al.*, 2015). Okafor *et al.* (2012) demonstrated that adding oyster (*Pluerotuspulmonaris*) mushroom powder to wheat flour used to make bread significantly improved the bread's protein content and nutritional quality. Ginger (*ZingiberOfficinale*) is a spice and flavoring agent that has many medicinal properties. In addition to enhancing flavor, herbs and spices are also known for their preservative, antioxidant, antimicrobial, and other medicinal properties (Sharifi-Rad *et al.*, 2017). According to Ezemba *et al.* (2021) reported the use of malted sorghum and ginger as flavor in the production of biscuits.

The production of composite flours from germinated *fonio*, mushroom, and ginger powder will mitigate biscuit diversification and its overall use in the baking industry. The aim of this study was to produce composite flour from germination *fonio*, mushroom, and ginger powder and assess the acceptability of the resulting biscuits.

2.0 Materials and Methods

Fonio (*Digitariaiburua*) grains was gotten from Kure Market, Minna Niger State, Nigeria. While mushroom (*Pleurotuspulmonarius*) used for this study was purchased from Sustainable Demonstration Farms Abuja, Nigeria. Ginger roots, corn starch, margarine, eggs, sugar, salt, milk, and baking powder were obtained from Kure Market, Minna Niger State, Nigeria.

2.1 Preparation of composite flours and biscuit from germinated *fonio* (*Digitaria. iburua*), mushroom (*Pleurotus. pulmonarius*) and ginger (*ZingiberOfficinale*) powder

Germinated *fonio* (*Digitaria. iburua*) flour was produced using the optimum germination period of 72 h reported by Bolarinwa *et al.* (2015). Two kilograms (2 kg) of the *fonio* were sorted to remove stones, dirt and other extraneous materials. The cleaned grains were thoroughly washed and steeped in water at room temperature 30 ± 2 °C for 12 h. The hydrated grains were spread on a previously sterilized moist jute bag and the grains were allowed to germinate for 72 h. Non-germinated grains were discarded and the germinated seeds were dried at 60 °C for 8 h in a cabinet dryer (model-RCD-20, Ningbo Belun Rhong, China). The withered rootless grains were gently winnowed, and the germinated grains were dry milled and sieved to produce germinated *fonio* flour (GF). Mushroom fruiting bodies, were washed thoroughly to remove mud, ferns and other extraneous material before oven (Model PSO-451 Presto Stantest Pvt. Ltd. India) dried at 50 °C for 8 h to obtain Mushroom flour (MF). Ginger rhizomes were cleaned and dried in a Presto laboratory hot air oven (Model PSO-451) at 50 °C for 8 h to obtain ginger powder (GP). Composite flours from different combination levels of germinated *fonio* (78-94%), mushroom (4 -19 %) and ginger flour (1-5%) were generated using I- optimal mixture using Design Expert (version 10, Stat-Ease Inc., USA). The proximate composition (method 925.10 for moisture, 923.03 for ash, 962.09 for fibre, 920.39 for fat, 955.04 for protein) of the samples were determined using

the AOAC (2012) procedures. Biscuits were produced using the mixing method described by Okpala and Okoli (2012) from the various composite blends of germinated *fonio*, mushroom and ginger. 100 % wheat flour biscuit was also produced and used as control. Other ingredients used in the production of biscuits were shortening (40g), sugar (30g) corn starch (1tsp), milk (15g), salt (1g) and baking powder (1tsp). The sensory analysis was carried out using 20 panellist constituting members of staff and students of Federal University of Technology, Department of Food Science and Technology, Minna, Nigeria. The sensory parameters; determined were appearance, colour, taste, aroma and general acceptability of the biscuits. Nine – point hedonic scale was used with 9= Like extremely ... to 1= dislike extremely. (Iwe, 2002).

3.0 Results and Discussion

3.1 Proximate composition of the composite flours

The result obtained from proximate composition of flour from blends of germinated *fonio*, mushroom and ginger powder are presented in Table 1. There were significant ($p \leq 0.05$) difference in the proximate composition of the flour blends. The moisture content of the composite flours were (5.95-6.70 %) this falls below the safe moisture level (≤ 10 g/100 g) for prolonged storage of flours. The protein content were between 9.42 – 15.25 % and fibre content were from 3.25 - 9.91 %. Sample L having the highest amount of protein (15.25 %) and Q having the highest amount of fiber (9.91 %). The high protein content in the composite flour could be as a result of mushroom inclusion and germination which involves synthesis of enzymes by germinating seed, change in composition resulting in newly formed protein. Low ash content were observed for the composite blends which were from 1.68-3.53 %, sample J shows highest amount of ash (3.53 %) and fat content were from 1.55-2.70 %. Mushrooms are not a choice of fats and the germination process also have been reported to reduce fat contents in seed as this is used up for energy for seed growth (Chinma *et al.*, 2021). Carbohydrate content of the composite blends were from 61.08 – 76.25 %. On the whole wheat flour had the lowest amount of ash (0.45 %) and fibre (1.30 %), while the wheat flour recorded highest amount of fat content and carbohydrate at 2.73 % and 77.47% respectively. Studies have shown that consumption of food rich in dietary fiber has protective effect against chronic diseases such as diabetes and cancer. This implies that the composite flours may be nutritionally more beneficial.

Table 3: Proximate composition of germinated *fonio* (*Digitaria. iburua*), mushroom (*Pleurotuspulmonarius*) and ginger (*ZingiberOfficinale*) composite flour blends

Runs	GF	MM	GG	Moisture content %	Protein %	Fibre (%)	Ash %	Fat %	Carbohydrate %
A	93.00	4.00	3.00	6.11±0.12	10.67±0.35	3.25±0.15	1.97±0.04	1.75±0.34	76.25±0.43
B	82.33	13.33	4.33	6.41±0.02	12.42±0.10	7.07±0.01	2.05±0.06	2.35±0.00	69.70±0.17
C	78.00	17.00	5.00	6.57±0.03	14.00±0.00	8.05±0.42	3.00±0.00	2.42±0.59	65.96±0.35
D	78.00	19.00	3.00	6.70±0.47	13.87±0.06	8.74±0.02	3.30±0.05	2.12±0.16	64.67±0.53
E	84.50	10.50	5.00	6.14±0.10	12.85±0.09	7.54±0.37	2.01±0.00	2.22±0.05	69.24±0.06
F	93.00	4.00	3.00	5.95±0.07	10.54±0.35	4.77±0.16	1.68±0.25	1.80±0.03	71.01±0.43
G	82.92	15.17	1.92	6.33±0.12	12.53±0.10	9.15±0.04	2.84±0.19	2.12±0.16	66.63±0.16
H	86.67	8.33	5.00	6.45±0.07	13.76±0.12	4.96±0.00	2.08±0.02	2.24±0.59	70.51±0.02
I	82.33	13.33	4.33	6.20±0.07	13.39±0.37	7.87±0.00	2.01±0.04	2.35±0.78	66.67±0.06
J	82.92	15.17	1.92	6.10±0.01	13.24±0.60	9.11±0.01	3.53±0.04	2.52±0.19	65.50±0.04
K	87.00	12.00	1.00	5.95±0.07	11.89±0.00	8.73±0.23	2.69±0.27	2.52±0.19	68.22±0.13
L	80.00	19.00	1.00	6.50±0.42	15.25±0.28	9.91±0.04	3.03±0.00	2.43±0.58	61.08±0.12
M	89.92	7.92	2.17	5.95±0.07	9.67±0.50	8.25±0.04	2.27±0.03	2.25±0.56	71.81±0.62
N	89.92	7.92	2.17	6.20±0.07	10.37±0.10	5.34±0.15	2.09±0.00	2.58±0.03	72.62±0.13
O	94.00	5.00	1.00	6.21±0.07	9.85±0.06	7.25±0.04	2.17±0.28	2.70±0.28	71.84±0.02
P	91.00	4.00	5.00	6.13±0.02	9.42±0.62	7.47±0.15	1.95±0.11	1.55±0.04	66.06±0.07
Q	87.00	12.00	1.00	6.17±0.07	13.29±0.27	9.75±0.37	2.00±0.00	2.02±0.00	66.77±0.00
CC	-	-	-	9.03±0.01	9.00±0.00	1.32±0.12	0.45±0.05	2.73±0.25	77.47±0.09

Each value is a mean of triplicate analyses ± standard deviation. All values are on dry weight basis

GF=Germinated *fonio* (*Digitariaiburua*), MM= Mushroom (*Pleurotuspulmonarius*), GG= Ginger powder, C= Wheat flour

3.2 Sensory properties of germinate *fonio* (*Digitariaiburua*), mushroom (*Pleurotuspulmonarius*) and ginger (*ZingiberOfficinale*) based biscuits

The results for the sensory analysis of the germinated *fonio*, mushroom and ginger biscuit is as presented in Table 2. The scores of all the sensory attributes were found to be statistically significant ($p \leq 0.05$) among the formulation combinations. Sample O (94:00%, 5.00%, 1.00%) scored the highest overall acceptability followed by sample N and P. The appearance were from 6.52-8.00 with run O having the highest value which is same with the control (CC). The sensory properties in term of taste, aroma, and crispness the composite flours

differ compared to the control wheat biscuit

Table 2: Sensory properties of germinated *fonio*(*Digitaria iburua*), mushroom (*Pleurotus. pulmonarius*) and ginger (*Zingiber Officinale*) based biscuits

Runs	Appearance	Colour	Taste	Aroma	Crispiness	Overall acceptability
A	7.10±0.19	7.00±0.17	6.80±0.29	6.65±0.27	7.00±0.12	7.05±0.27
B	6.52±0.11	6.14±0.12	6.52±0.22	6.14±0.15	6.81±0.13	6.24±0.20
C	7.25±0.14	7.30±0.14	6.25±0.19	6.40±0.15	6.85±0.13	5.85±0.27
D	7.00±0.13	6.95±0.09	6.16±0.25	6.21±0.27	6.42±0.15	6.21±0.23
E	6.95±0.08	6.85±0.10	6.05±0.26	6.20±0.26	6.35±0.19	6.05±0.26
F	7.35±0.11	7.15±0.15	7.00±2.05	6.95±0.21	7.10±0.17	7.05±0.19
G	7.30±0.14	7.25±0.12	7.25±0.16	6.85±0.16	7.15±0.13	7.10±0.12
H	7.30±0.14	7.25±0.12	7.25±0.16	6.85±0.16	7.15±0.13	7.10±0.12
I	7.45±0.11	7.20±0.09	6.20±0.32	6.35±0.31	6.05±0.35	6.36±0.32
J	6.95±0.11	6.95±0.08	6.35±0.33	6.50±0.18	6.50±0.19	6.35±0.22
K	7.35±0.19	6.85±0.18	6.85±0.18	6.85±0.18	6.85±0.18	6.85±0.18
L	7.00±0.00	6.85±0.10	6.40±0.16	6.45±0.13	6.50±0.13	6.35±0.18
M	7.60±0.15	7.60±0.15	7.60±0.15	7.60±0.15	7.60±0.15	7.60±0.15
N	7.80±0.22	7.80±0.22	7.80±0.22	7.80±0.22	7.80±0.22	7.80±0.12
O	8.20±0.17	8.25±0.17	8.70±0.10	8.55±0.17	8.07±0.11	8.00±0.70
P	7.70±0.21	7.70±0.21	7.70±0.21	7.00±0.21	7.70±0.21	7.70±0.11
Q	7.40±0.23	7.40±0.23	7.40±0.2	7.40±0.23	7.40±0.22	7.40±0.23
CC*	8.00±0.80	6.90±1.32	7.00±1.50	6.80±1.5	7.80±1.50	7.80 ±1.32

Each value is a mean of triplicate analyses ± standard deviation. CC*= Wheat flour biscuit

4.0 Conclusion

The proximate composition of blends of germinated *fonio*, mushroom, and ginger composite flour and the sensory attribute of the biscuit were evaluated in this study. The study shows that there were significant difference ($p \leq 0.05$) in the proximate composition of the composite flour and sensory attribute of the biscuit. the proximate composition reveals that the moisture content were from 5.95-6.70%, the protein and fiber content were from 9.42- 15.25 % and 3.25- 9.91%, respectively, and the ash, fat, and carbohydrate content were from 1.68-3.53%, 1.55-2.70%, and 61.08-76.25%. Depending on the proportion, the protein and ash contents of the flour blends increased. The high protein content of the

composite flour may be due to mushroom inclusion and germination, which involves enzyme synthesis by germinating seed. All of the composite flours were successful in producing acceptable biscuits with sample O having the highest overall acceptability.

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PRODUCTION AND QUALITY EVALUATION OF BEETROOT-COLORED STEW PASTE FROM CARROT (*DAUCUS CAROTA* VAR SATIVUS) AND CAYENNE PEPPER (*CAPSICUM ANNUM*)

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Abstract

Most tomato pastes sold in Nigeria are made with a lot of artificial food coloring and other non-tomato based ingredients such as starch, sugar and thickeners. This will obviously reduce the quantity of lycopene and other beneficial nutrients and introduce additives that may be harmful to the human body. Carrot, beetroots and cayenne pepper are colored plant foods loaded with a lot of nutrients and phytochemicals. The aim of the study was to produce two varieties of carrot-pepper paste:- 70 carrot:30 cayenne pepper and 50 carrot: 50 cayenne pepper colored with beetroot and to compare their chemical and sensory qualities with that of a selected commercial tomato paste.. Ash (1.35 ± 0.41)%, fat (0.94 ± 0.04)%, moisture(86.66 ± 0.61)%, potassium (425.48 ± 0.43)mg/100g, Iron (3.53 ± 0.20)mg/100g and viscosity (197.44 ± 1.08)m.pas were higher in 70 carrot: 30 cayenne pepper paste. The sample consisting of 50 carrot: 50 cayenne pepper showed higher protein (2.22 ± 0.08)%, magnesium (89.7 ± 0.1)mg/100g, Calcium(149.17 ± 1.05)mg/100g, phosphorous(32.31 ± 1.11)mg/100g, carotenoids(19.47 ± 0.41)mg/100g, polyphenols (563.97 ± 3.72)mg/100g and chlorophyll(7.16 ± 0.14 and 11.69 ± 0.32) values. The color of the 70 carrot:30 cayenne pepper paste was more acceptable(7.8 ± 0.9) and overall acceptability(6.2 ± 2.3) not significantly different from the tomato paste market sample. The two varieties of beetroot-colored tomato: cayenne pepper stew pastes showed higher nutritional values and acceptable sensory values compared to commercial tomato paste.

Keywords: Stew paste, Carrot, Cayenne pepper, Beetroot, Tomato paste

Introduction

The obvious high percentage of artificial food coloring and other non-tomato ingredients used in the formulation of most commercial tomato paste brands in recent times in Nigeria has become worrisome, especially to health-conscious consumers. Tomatoes are the most popular condiment for the preparation of stew paste. Tomato paste is a thick concentrate made by boiling deseeded and pureed tomatoes for several hours. It is used in the preparation of stews, sauces, porridge, etc.. Tomato paste is a popular food commodity in Nigeria as it is used in the cooking of major staples like rice dishes, sauces and stews. Most tomato pastes sold in Nigeria appear adulterated with starch, paprika seeds, salt, sugar and artificial food coloring (Onyeaghala *et al*, 2016; Vitalis *et al*. 2020). The level of adulteration varies with brands and might reduce nutrients and phytochemical composition (Onyeaghala *et al*, 2016). This trend becomes worrisome with the rising prevalence of metabolic diseases like cancer, hypertension, diabetes, hypersensitivity in children, etc which are related to diet.

Stew paste prepared from a blend of carrots, cayenne pepper and beet roots may positively compete with tomato stew paste in textural, nutritional and sensory qualities and could even contain more natural bioactive components devoid of synthetic food additives.

Carrot (*Daucus carota* var *sativus*) and cayenne pepper (*Capsicum annum*) share similarities with tomatoes (*Solanum lycopersicum*) in being carotenoids-rich plants foods. Carrot contains more calories, carbohydrate, protein, dietary fiber and lipids than tomatoes. Again, carrots rate higher in all the major and minor micronutrients than tomatoes, except vitamin C. Carrots also contain more bioactive components such as anthocyanins and carotenoids such as beta-carotenes, alpha-carotene, lutein and zeaxanthin. According to a report by Mills *et al.*, (2007), the beta-carotene from carrots maintained better provitamin A activity more than in tomatoes, however, lycopene bioavailability was lower in carrots than tomatoes. Beta-carotene has a pro-vitamin A activity and is a powerful antioxidant. This protects the body against damage from free radicals which result in progression of several degenerative diseases. A diet rich in carrots protects the eyes, lowers risk of cancer and heart disease, alleviates constipation, boosts the immune system and controls diabetes.

Beets (*Beta vulgaris* subsp. *vulgaris*) are rich dietary sources of nutrients and bioactive components such as betalains. Betalains is responsible for the red and yellow pigments of beetroots. Cayenne pepper (*tatashe*) has been used as a medicinal plant since ancient times. It contains bioactive compounds such as capsaicin. Capsaicin may alleviate the symptoms of heart disease and diabetes.

As condiment for preparation of stew paste, tomatoes presents better alternatives than carrot because of the color appeal and presence of umami compounds such as glutamic acid. However, these shortcomings can be overcome by supplementation of the carrots with beets and cayenne pepper. Beet has a rich deep purplish-red color. Cayenne pepper is aromatic and flavorful and has a rich and stable red color which finds applications in food coloring. Besides the creation of novel foods and provision of varieties, these may enhance the overall sensorial appeal of the novel stew paste as well as boost its nutrients, micronutrients and carotenoids composition. The aim of this study was to produce and assess the nutritional, physicochemical and sensory qualities of stew paste from two blends of beetroot-colored carrot and cayenne pepper.

Materials and Methods

Sample procurement

Fresh carrot (*Daucus carota* var *sativus*), cayenne pepper (*tatashe*) (*Capsicum annum*), beetroot (*Beta vulgaris* subsp. *vulgaris*), commercial tomato brand, olive oil, salt and citric acid were bought from a local market, Afor Nkpor, Nkpor, Idemili North LGA, Anambra State. The carrot (*Daucus carota* var *sativus*), cayenne pepper (*tatashe*) (*Capsicum annum*), beetroot (*Beta vulgaris* subsp. *vulgaris*) were identified at the Department of Crop Science, Chukwuemeka Odumegwu Ojukwu University, Igbariam, Anambra State.

Preparation of carrot paste and sensory evaluation

Two carrot-pepper blends were prepared at 50:50 and 70:30 ratios of carrot and cayenne pepper respectively. The product formulation for the 50:50 blend was: carrot (50g), cayenne pepper (50g), beetroot (20g), olive oil (5mL), salt(4g), citric acid (2mL), while the product formulation for the 70:30 blend was: carrot (70g), cayenne pepper (30g), beetroot (20g), olive oil (5mL), salt(4g), citric acid (2mL). The carrot was slightly scraped, washed, sliced in tiny cubes, while the beetroot was thoroughly washed both were placed in a sauce pan. About 100mL of water was added and the carrot and beetroot were simmered for 45 minutes each. The skin of the beetroot was removed. The cayenne pepper was deseeded and washed. The boiled carrot and beetroot and cayenne pepper with salt, olive oil and citric acid were placed in a blender and pureed to smoothness. The mixture was concentrated for 30 minutes in a grease-proof saucepan with constant stirring and further placed on baking sheets and spread thinly. The baking sheets were placed in an oven and heated at 70°C for 4 hours. The paste were ready when the paste developed shiny surface and the quantity reduced by more than half. The paste were scooped into glass sample bottles, covered, labeled and stored in the freezer until they were analysed. Three samples were used for analyses: a commercial brand of tomato paste (Tasty tom), 70:30 carrot-pepper and 50:50 carrot-pepper blends.

Ten-member panelists drawn out from students and staff of the Department of Food Science Chukwumeka Odumegwu Ojukwu University, Anambra State carried out a sensory evaluation on the three samples. The parameters analysed were: appearance, aroma, taste, texture, mouth-feel, after taste and overall acceptability.

Chemical analysis and Statistical analysis

Proximate, micronutrient and heavy metal compositions of the samples were determined (AOAC, 2006). Physicochemical composition such as total soluble solids, titratable acidity, pH, viscosity and color were determined (Onwuka, 2005), while phytochemicals such as carotenoids, polyphenols, chlorophyll a and chlorophyll b were also determined (Onwuka, 2005).

All determinations were analyzed in triplicates using the Completely Randomized Design (CRD). The data obtained was analysed using one-way analysis of variance (ANOVA) in the Statistical Packaging for Social Sciences (SPSS) statistical software, version 21. Statistical differences of the mean samples were determined using the least significance difference (LSD) ($p < 0.05$).

Results and Discussions

The data in Table 1 showed the comparative quality evaluation of two varieties of carrot and cayenne pepper stew paste and commercial tomato paste brand. Moisture content, protein, fat, ash, fiber and carbohydrate ranged from 78.22-84.09%, 1.75-2.22%, 0.86-0.94%, 0.88-1.35%, 3.43-3.460%; vitamins E and C, potassium, sodium, iron, magnesium, calcium and phosphorous ranged from 0.00-1.38 mg/100g, 15.53-26.19 mg/100g, 364.14-425.48 mg/100g, 54.33-115.45 mg/100g, 0.91-3.52 mg/100g, 84.39-89.70 mg/100g, 140.23-149.17 mg/100g and 28.50-32.31 mg/100g. The carotenoids, polyphenols, chlorophyll a and b were found to range from 7.56-19.47mg/100g, 511.64-563.9mg/100g, 0.04-7.16µg/g and 0.34-

11.69µg/g respectively. The soluble solids, acidity, pH, color and viscosity ranged from 24-28%, 0.53-1.21%, 4.64-5.56, 130.33-330.47ASTA color values and 196.4-285.46m.Pas respectively. The values for lead and mercury ranged from 0.16-0.19mg/100g; and 0.00-0.03 µg/100g respectively. The appearance, aroma, taste, texture, mouthfeel, aftertaste, acceptability and average sensory score ranged from 7.2-7.8; 6.4-7.4; 5.2-7.1; 6.1-7.8; 5.7-7.4; 4.7-6.3; 5.5-6.9 and 5.9-7.27 respectively.

Protein content was highest (2.22%) in the 50:50 carrot:cayenne pepper (CCP) and lowest (1.75%) in the tomato paste sample. Highest protein value of the 50:50 (CCP) sample could be as a result of increased substitution with pepper. Ash content was highest in the 70:30 (CCP). Carrots have appreciable quantity of minerals than tomatoes as ash content indicates higher presence of minerals. There was no significant difference in the crude fiber content of all the samples. 70:30 (CCP) showed higher fat content (0.94%) which was comparable to tomato paste (0.93%) but decreased with increased pepper substitution in the 50:50 (CCP) sample (0.86%). Increased pepper substitution also reduced moisture content as the 70:30 (CCP) sample had higher moisture (86.66%) value than the 50:50 (CCP) sample. However, the tomato paste had the lowest moisture value (78.22%). Foods within the moisture content of 0.87–0.80% are easy substrates for mould growth. Carbohydrate was highest in the market tomato paste sample and lowest in the 70:30 (CCP) sample, The proximate content values were comparable with those obtained by Abdullahi *et al.*, (2016).

Tomato paste sample had the highest vitamin C (26.19mg/100g) and vitamin E (1.38mg/100g) contents), while 70:30 (CCP) had the lowest vitamin C (15.53mg/100g) and vitamin E (0.00mg/100g) contents. Tomatoes have appreciable quantities of vitamin C than carrots (Onyeaghala *et al*, 2016). Seed oils are the only important plant sources of vitamin E. Other plant sources have less than 0.5mg/100g. Potassium was highest (425.48mg/100g) in the 70:30 (CCP) sample. This is almost equal to 10% of the recommended daily allowance RDA for potassium which is 4700 mg. The highest sodium content (115.47mg/100g) in the canned tomato paste sample could be as a result of higher added salt during product formulation. Sodium in the diet is a risk factor for development of hypertension. Iron content was also highest (3.52mg/100g) in the 70:30 (CCP) sample. This is up to 40% of the RDA for iron for both men and women. Increased pepper substitution reduced the iron content as the 50:50 (CCP) was the lowest value in iron (0.91 mg/100g) in all the three samples. Magnesium and calcium contents were significantly highest (89.70 mg/100g and 149.17 mg/100g respectively) in the 50:50 (CCP) more than in the other samples, followed by 70:30 (CCP) (88.40 mg/100g and 147.28 mg/100g respectively) and least in canned tomato paste. The magnesium and calcium contents were up to 15% RDA for both calcium and magnesium. Phosphorous was also highest (32.32 and 31.08 mg/100g) in the 50:50 and 70:30 (CCP) samples than in the tomato paste sample (28.50 mg/100g). The micronutrient values were comparable with those obtained in Abdullahi *et al.* (2016).

The 50:50 (CCP) significantly had higher values of carotenoids (19.47mg/100g), polyphenol (563.97mg/100g) chlorophyll a (7.16(µg/g) and chlorophyll b (11.69 µg/g) contents than other samples. The carrot:cayenne pepper samples also showed significantly higher overall phytochemical values than the tomato paste sample. The combination of carrots, pepper and

beet roots would have increased the overall phytochemical contents of the (CCP) samples. Phytochemicals protects the body against chronic diseases, and help in the regulation of hormonal functioning (Prakash *et al.*, 2012).

Titratable acidity, total soluble solids and viscosity were highest in the tomato paste sample, 1.21%, 1.38% and 285.46 m.pas respectively. This could be explained by the lower moisture content. However, increased pepper substitution increased color value as the 50:50 CCP sample had the highest color value (330.47 ASTA). There was no heavy metal toxicity in the samples as all the samples had values below the 2.2 µg/100g lower limit for lead and mercury allowable in foods (USFDA, 2022). From the sensory analysis, the color of the 70:30 CCP sample was more acceptable (7.8) and overall acceptability (6.2) and mean sensory scores not significantly different from the tomato paste market sample.

Table 1: Comparative Quality evaluation of two varieties of beetroot-colored carrot and cayenne pepper stew paste and commercial tomato paste brand.

Parameters	Commercial tomato paste brand (Tasty Tom)	70:30 Carrot-Cayenne pepper paste (70:30 CCP)	50:50 Carrot-Cayenne pepper paste (50:50 CCP)
Proximate Composition			
Moisture%	78.22 ^c ±0.82	86.66 ^b ± 0.82	84.09 ^a ± 0.82
Protein%	1.75 ^a ±0.33	2.03 ^b ± 0.03	2.22 ^c ±0.08
Fat%	0.93 ^a ± 0.01	0.94 ^a ± 0.04	0.86 ^a ±0.06
Ash%	0.88 ^a ±0.8	1.35 ^b ±0.41	0.94 ^a ±0.35
Fiber%	1.46 ^a ± 0.04	3.43 ^b ±0.03	3.44 ^c ± 0.03
Carbohydrate%	16.76 ^c ±0.14	5.59 ^a ±0.56	8.47 ^b ±0.41
Micronutrients			
Vitamin C (mg/100g)	26.19 ^c ±0.17	15.53 ^a ±0.07	18.12 ^b ±0.04
Vitamin E (mg/100g)	1.38 ^c ±0.02	0.00 ^a ±0.00	0.29 ^b ±0.05
Potassium (mg/100g)	382.00 ^b ±1.95	425.48 ^c ±0.43	364.14 ^a ±2.07
Sodium (mg/100g)	115.47 ^c ±0.11	96.68 ^b ±0.40	54.33 ^a ±0.28
Iron (mg/100g)	1.08 ^a ±0.1	3.52 ^b ±0.20	0.91 ^a ±0.04
Magnesium (mg/100g)	84.39 ^a ±0.54	88.40 ^b ±0.4	89.70 ^c ±0.1
Calcium (mg/100g)	140.23 ^a ±0.2	147.28 ^b ±0.27	149.17 ^c ±1.05
Phosphorous(mg/100g)	28.50 ^a ± 0.1	31.08 ^b ± 0.04	32.31 ^b ± 1.11
Phytochemicals			
Carotenoids (mg/100g)	7.56 ^a ±0.26	8.15 ^b ±0.74	19.47 ^c ±0.41
Polyphenols(mg/100g)	511.64 ^a ± 1.13	525.97 ^b ± 5.19	563.9 ^c ± 3.72
Chlorophyll a (µg/g)	0.046 ^a ±0.04	2.12 ^b ±0.08	7.16 ^c ±0.14
Chlorophyll b (µg/g)	0.34 ^a ±0.12	3.72 ^b ±0.25	11.69 ^c ±0.32
Physicochemicals			
Total soluble solids %	28 ^c ±0.1	25 ^b ± 0.03	24 ^a ± 0.13
Titratable acidity%	1.21 ^a ±0.2	0.78 ^a ±0.05	0.53 ^a ±0.09
Ph	4.71 ^a ±0.09	5.56 ^b ±0.164	4.64 ^a ±0.1
Viscosity (m.pas)	285.46 ^b ±1.17	197.44 ^a ±1.08	196.4 ^a ±1.08
Color (ASTA color values)	138.83 ^b ± 0.76	130.33 ^a ±1.16	330.47 ^c ±1.86
Heavy metals			
Lead(µg/100g)	0.18 ^a ±0.03	0.16 ^a ±0.05	0.19 ^a ±0.09
Mercury (µg/100g)	0.03 ^a ±0.01	0.00 ^a ±0.00	0.00 ^a ±0.00
Sensory Evaluation			

Color	7.2 a $\pm$ 1.6	7.8 a $\pm$ 0.9	7.3 a $\pm$ 1.3
Aroma	7.4 a $\pm$ 1.2	6.6 a $\pm$ 1.4	6.4 a $\pm$ 2.1
Taste	7.1 b $\pm$ 1.3	6.0 a $\pm$ 1.8	5.2 a $\pm$ 2.15
Texture	7.8 a $\pm$ 1.5	6.5 ab $\pm$ 1.3	6.1 a $\pm$ 1.5
Mouthfeel	7.4 b $\pm$ 1.07	6.6 ab $\pm$ 0.8	5.7 a $\pm$ 1.8
After taste	6.3 a $\pm$ 1.5	6.0 a $\pm$ 1.4	4.7 a $\pm$ 2.06
Overall acceptability	6.9 a $\pm$ 2.4	6.2 a $\pm$ 2.3	5.5 a $\pm$ 2.7
Mean score of sensory values	7.27 b $\pm$ 1.02	6.6 ab $\pm$ 0.6	5.89 a $\pm$ 1.4

Data values are expressed as means of triplicates $\pm$ standard deviation. Values in the same row with the same superscript are not significantly different ($p < 0.05$). Values of sensory scores were: 9= liked very much;

Conclusion

The beetroot-colored 70carrot: 30cayenne pepper and 50carrot:50 cayenne pepper showed significantly higher protein, ash, fat, micronutrients and phytochemical values with no heavy metal toxicity than the tomato paste market sample. They also showed acceptable sensory values compared with commercial tomato paste.

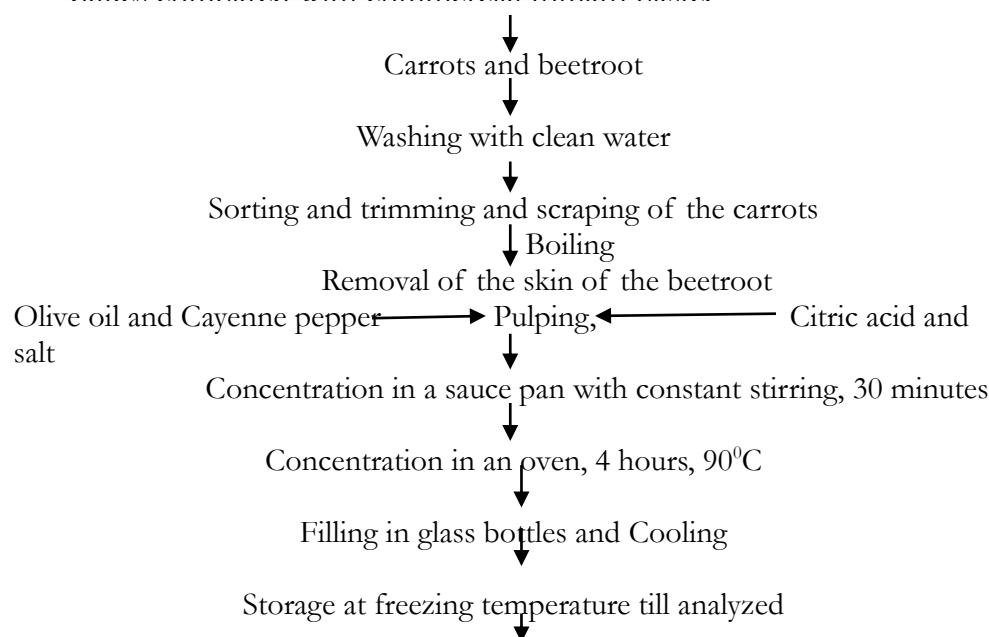


Figure 1: Flow diagram for the production of beetroot-cored carrot: cayenne pepper paste

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PRODUCTION AND CHARACTERIZATION OF OILS FROM ALMOND, AVOCADO AND COCONUT FRUITS

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Abstract

This work focused on extraction and characterization of oils from almond, avocado and coconut. Oil extraction was done after cleaning, weighing and grating of the oil seeds. The oils were analysed for physicochemical properties and fatty acid profiles using standard methods. The data generated were subjected to Analysis of Variance and means separated using Duncan Multiple Range test at significance level of $p < 0.05$. Almond and avocado oils, were lower and higher than coconut oil in moisture and iodine value respectively. Almond and coconut oils were lower than avocado oil in terms of acid value and free fatty acid. Almond and coconut oils were higher in specific gravity than almond. There was significant difference in capric and behenic acids of the oils. While myristic, palmitic and stearic acids were not detected in almond and avocado oils, coconut oil had the acids. For oleic and linoleic acids, they were detected in almond and avocado oils; respectively. Significant difference existed in eicosatrienoic acid of avocado and coconut oils but could be detected in almond oil. The oils could be utilized singly or blended for different applications in food industries since most of their properties differed.

Keywords: Almond, Avocado, Coconut, Oil, Characterization

Introduction

Coconut (*Cocos nucifera*) is extensively grown in Philippines with approximately 12 million hectare in cultivation (Moreno *et al.*, 2020). In many parts of the world, oil, meat, juice and milk are derived from coconut. A good percentage (37%) of coconut is processed into coconut oil and other secondary processed products (Moreno *et al.*, 2020).

Almond (*Prunus dulcis*) is cultivated largely in California and constitutes the most important nut in the world in terms of commercial production (Kodad *et al.*, 2014). The kernel is the edible part of the almond nut and it is of high nutritional value. The components of almond are lipid, protein, soluble sugars, mineral, fibre and phytochemicals. Almond oil is a transparent and light yellow oil that is used as cooking oil (Kodad *et al.*, 2014).

Avocado (*Persea americana*) is a fruit native to Central America, grown in warm temperate and subtropical climates throughout the world (Carvajal-Zarrabá *et al.*, 2014). Its oil is used as cooking oil and it has industrial applications. Avocado oil has generated growing interest among consumers due to its nutritional and technological characteristics, which is evidenced

by the increase in the number of scientific articles that has been published on it. Some studies indicate that the quality of avocado oil depends on the quality and maturity of avocado fruit and the extraction technique in relation to temperature, solvents and conservation (Carvajal-Zarrabale *et al.*, 2014).

Furthermore, due to high demand for vegetable oils which resulted from the population growth, rising standards of living, consumer preference and health consideration, there is need to evaluate other seeds for oil production. Therefore, this work focused on the production and characterization of oils from almond, avocados and coconut fruits.

Materials and Methods

Materials

Coconut, almond and avocado were purchased from Wazo Market, Ogbomoso, Oyo State, Nigeria. The chemicals used were of analytical grade.

Production of oils from oilseeds

Oil extraction was carried out using the traditional method. The oil seeds were weighed and cleaned. They were then crushed and ground into fine paste. The paste was mixed with warm potable water and kneaded to exude oil which was collected for analyses.

Determination of physicochemical properties

Moisture content, saponification value, free fatty acid, iodine value, specific gravity, acid value, peroxide value were determined using standard method (AOAC, 2001). While the fatty acid profiles of oils were determined using gas chromatography (GC).

Statistical analysis

The data generated were subjected to analysis of variance (ANOVA) and the means were separated with the use of Duncan's Multiple Range Test (DMRT) to detect significant difference ($p < 0.05$) among the samples.

Results and discussion

Physicochemical properties

The results of physicochemical properties of almond, avocado and coconut oil samples were presented in Table 1. The moisture contents ranged from 5.53 to 7.53% with almond oil having the highest value and coconut oil having the least value. While there was significant difference in the moisture content of almond and coconut oils, there was no significant difference in the oils got from almond and avocado or the oils from avocado and coconut. The moisture contents of the oil samples were high compared to the maximum allowed moisture content (0.2%) in edible oils (Codex, 2009). The relatively high moisture of the oils in this study could be due to inefficient moisture removal process employed. As a result of high moisture content of the oils, the oils may be susceptible to hydrolytic rancidity thereby reducing the shelf-life of the oils.

Saponification value (SV) ranged from 168.33 to 299.20% with coconut oil having the highest value and almond oil having the lowest value. There were significant differences in

the SV of the oil samples. While the SV of almond and coconut oils were not within the standard limit ranged whereas that of avocado oil was within the limit ranged of (248-268 mg KOH/g oil) being set by Asian Pacific Coconut Community (APCC), whereas, none of the SV met the standard (250-260 mg KOH/g oil) set by Codex Alimentarius (Codex, 2009). The low and high SV in almond oil and coconut oil are indicative of low impurities and high level of impurities, respectively (Codex, 2009). The high SV of coconut oil could also be as a result of high concentration of short and medium chain triglycerides.

The free fatty acid (FFA) value ranged from 0.66 to 0.85% with oil from avocado having the highest value and the coconut oil having least value. The FFA of the oils compare well with 0.700% for virgin coconut oil stored at 28 °C for 90 days and close to the stipulated limit (0.5%) set by APCC. The relatively high FFA is an indication of rancidity which could have stemmed from high moisture of the oil. Since the FFA values of all the oil samples fall within <1.00 (Indian Standard), the oils could still be regarded as chemically safe to be used in food operations (Codex, 2009).

Table 1: Physicochemical properties of oil samples

Sample	Moisture (%)	Saponificati on values	Free fatty acid (%)	Iodine values (g I ₂ /g oil)	Specific gravity	Acid values (%)	Peroxide value (meq/kg oil)
Almond oil	7.53±0.76 ^b	168.30±0.01 ^a	0.67±0.09 ^a	4.10±0.07 ^b	0.925±0.00 ^a	1.33±0.18 ^a	14.67±0.24 ^b
Avocado oil	7.40±1.25 ^{ab}	261.80±0.13 ^b	0.85±0.28 ^b	4.32±0.00 ^b	0.933±0.00 ^b	1.68±0.56 ^b	21.67±1.16 ^c
Coconut oil	5.53±0.50 ^a	299.20±1.14 ^c	0.66±0.16 ^a	3.26±0.19 ^a	0.931±0.00 ^b	1.81±0.32 ^a	8.83±0.29 ^a

Means are values of three readings. Means with same superscript along the same column are not significantly different (p<0.05).

The iodine value (IV) ranged from 3.26 to 4.32 g I₂/g oil with avocado oil having highest value and coconut oil having the least value. These values are below the ranges 6.3-10.6 and 4.1-11 stipulated as standards by Codex Alimentarius and APCC (Codex, 2009). There was significant difference in the IV of the oil from coconut and the oils from almond and avocado. Since IV of almond and avocado oils were higher than that of coconut, they would have higher content of unsaturated fatty acids which may make them suitable for

formulating healthy diets. However, the oils from almond and avocado may be more prone to rancidity than the oil from coconut.

The specific gravity (SG) of the oils ranged from 0.925-0.933 with the SG of oil from almond being significantly higher than that of the oils from avocado and coconut. Nevertheless, these SG values of the samples are comparable to the values (0.9162-0.952) reported for cold and hot pressed coconut oil and are suggesting each of the oils could be used on a commercial scale (Codex, 2009).

The acid value (AV) ranged from 1.33 to 1.81%. The oil from coconut had the highest AV whereas oil from almond had the least. The lower the AV of an oil the fewer the FFA and the better the quality of the oil. However, the AV of all the oil samples were higher than 0.1% for an oil suitable for edible purposes (Codex, 2009). However, almond and avocado oil could still be considered for human consumption with improvement in refining.

The peroxide value (PV) ranged from 8.83 to 14.67 meq/kg oil. The oil from avocado had the highest PV whereas the one from coconut had the least value. The PV is a factor in determining the susceptibility of oil to oxidative rancidity. The PV of the oil from coconut is within the limit of <10 meq/kg stipulated by Codex Alimentarius (Codex, 2009).

Fatty acid Profiles of oil samples

The fatty acid profile of the oil samples are shown in Table 2. The saturated fatty acid present in the oils extracted included arachidic acid, behenic acid, capric acid, myristic acid, palmitic acid and stearic acid. While the unsaturated fatty acid present in the oils were linoleic, oleic and eicosatrienoic acids. Almond had 0.96% capric acid, 8.13% oleic acid and 90.8% behenic acid. Myristic, palmitic, linoleic, arachidic, eicosatrienoic acids were not detected in the oil samples. The result obtained in this study is contrary to 60 % oleic acid previously reported for almond oil (Gabriel *et al.*, 2017). Meanwhile, avocado oil had 2.34% of capric, 5.35% linoleic, 24.28% arachidic, 66.50% behenic and 1.35% eicosatrienoic acids. Coconut oil had 8.12% capric acid, 7.12% myristic acid, 44.9% palmitic acid, 19.33%, stearic acid, 8.87% arachidic acid, 8.87% behenic acid, 2.65% eicosatrienoic acid. The numerous benefits of coconut oil can be attributed to the presence of different fatty acids as reported by (Prapunet *et al.*, 2016).

Table 2: Fatty acid profile (%) of almond, avocado and coconut oil.

Sam ples	C _{10:0}	C _{14:0}	C _{16:0}	C _{18:0}	C _{18:1}	C _{18:2}	C _{20:0}	C _{22:0}	C _{20:3}
Alm ond Oil	0.96±0.01 ^a	ND	ND	ND	8.13±0.15 ^a	ND	ND	90.84±0.18 ^c	ND
Avo cad o Oil	2.34±0.02 ^b	ND	ND	ND	ND	5.34±0.02 ^a	24.28±0.02 ^b	66.51±0.03 ^b	1.35±0.07 ^a
Coc onu t Oil	8.12±0.02 ^c	7.12±0.02 ^a	44.97±0.02 ^a	19.33±0.02 ^a	ND	ND	9.05±0.02 ^a	8.70±0.02 ^a	2.65±0.01 ^b

Means with same superscript along the same column are not significantly different ($p < 0.05$).

Key: C_{10:0} - Capric acid, C_{14:0} - Myristic acid, C_{16:0} - Palmitic acid, C_{18:0} - Stearic acid, C_{18:1} - Oleic acid, C_{18:2} - Linoleic acid, C_{20:0} - Arachidic acid, C_{20:3} - Eicosatrienoic acid and C_{22:0} - Behenic acid, ND - Not detected

Capric acid and Behenic acid were detected in all the three oil samples. There was significant difference observed among the samples. Sample A had the highest while sample B had the least value.

Myristic acid was found in coconut oil only with a value of 7.12%. This could make coconut oil be suitable for the production of skincare and hair care product (Kapila, 2016). Palmitic acid was also found in coconut oil to the tune of 44.97%. Coconut oil could be found useful as palmitic acid supplement (Santa, 2019) and due to its antioxidant properties, it could help in preventing free radical damage to the skin. Eicosatrienoic acid and arachidic acid which are unsaturated fatty acids were detected in avocado oil and eicosatrienoic acid was present in both coconut oil and avocado to the tune of 2.65% and 1.35%, respectively.

Oleic acid was detected in avocado oil. This may confer the ability to improve heart conditions by modulating cholesterol and reducing inflammation in humans on avocado oil as oleic acid contributes to these functionalities (Sergio *et al.*, 2016). The percentage of eicosatrienoic acids found in avocado and coconut oils were 1.35% and 2.65%, respectively. These oils could be useful in lowering blood pressure, especially in people living with hypertension (Sergio *et al.*, 2016).

From the results obtained almond oil had 91.76% saturated fatty acid and 8.13% unsaturated fatty acid and avocado oil had 77.54% saturated fatty acid and 6.69% unsaturated fatty acid. Meanwhile, coconut oil had 93.22% saturated fatty acid and 2.65% unsaturated fatty acid. Since unsaturated fats are generally regarded to be healthier in the diet than saturated fats because they may help lower the level of cholesterol in the blood, almond oil would be more preferred for human consumption.

Conclusion

The physicochemical properties and fatty acid profile of the oil samples indicate that oils from almond and avocado showed a superior quality over the oil from coconut. However, all the oil samples may need more refining to meet the standards set by both local and international food regulatory agencies.

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COMPARATIVE PHYSICO-CHEMICAL COMPOSITION AND MINERAL CONTENT OF THREE INDIGENOUS TOMATO CULTIVARS

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Abstract

Understanding the quality attributes of crops is important to determine their utilization and value in any improvement program. Fruits of three indigenous cultivars of tomatoes, Ibadan Local (IbL), Ife, and JM 94/46 were analyzed for physico-chemical and minerals content. Vitamin C content was not significantly different among the three cultivars ranging between 47.97 ± 0.18 and 48.34 ± 0.60 mg/100g. Soluble solids and total acidity were significantly different ($P \leq 0.05$) with IbL highest at $6.39 \pm 0.12^\circ\text{Brix}$ and $65.58 \pm 0.98\%$ respectively. Moisture was not significantly different between IbL and Ife but was significantly different with JM with highest moisture content of 93 ± 0.62 . Among the cultivars, the sodium, potassium, phosphorus, zinc and copper contents were significantly different ($P \leq 0.05$) while magnesium was not significantly different ($P \geq 0.05$). Sodium was 11.53 ± 0.07 , 10.29 ± 0.03 and 6.41 ± 0.02 mg/100g in Ife, IbL and JM respectively. Magnesium and calcium measured at approximately 11mg and 13mg /100g respectively were higher than recorded in some commercial cultivars. Iron was detected only in Ife and JM. Some lead, probably contaminant from the soil was detected in Ife and JM at 1.22 ± 0.13 and 0.05 ± 0.02 mg/100g respectively. This study provides necessary physico-chemical and nutritional data on our indigenous germplasm for research and economic purposes.

Keywords: Tomato, Indigenous cultivars, Physico-chemical attributes, Mineral content,

Introduction

Globally, tomatoes (*Solanum lycopersicum*) are the most important vegetable crop with estimated production of about 180.8 million tons in 2019 (FAO, 2020) supporting the livelihood and improving the economic life of many of its breeders. As one of the most important vegetables in the world, there is increased interest in the improvement of tomato due to its nutritional, economic and social benefits. This has led to the consistent and intensified exploitation of exotic resources and the introgression of new valuable genes into the tomato gene pool which is required to create new cultivars with highly marketable values and quality sensory parameters (Felföldiet al., 2022). Classical breeding has not only developed cultivars

with monogenic and dominant resistance for controlling certain plant pathogens, but has also enabled the acquisition of value-added agronomic traits, such as high fertility and fruit setting, uniformity, adaptability, firmness and long shelf-life appropriate for shipping to distant markets (Ray, 2011).

The tomato fruit is highly perishable, has a short shelf life at ambient temperature, and is not available throughout the year. The chemical composition of the tomato fruit is highly dependent on environmental factors (light, temperature, mineral nutrition, and air composition), cultivation technology, genetic differences (cultivar variety), agricultural practices (ripening stage at harvest and irrigation system), biotic and abiotic stresses, and post-harvest storage (Bharambeet *al.*, 2016). This composition in turn affects the nutritional, sensory, and shelf stability attributes, which ultimately influences consumer preference and marketability. The present study aimed at carrying out a comparative analysis of physico-chemical and mineral content of promising indigenous cultivars reported to be disease resistant and relatively high yielding (Badraet *al.*, 1984) with a view to getting evidence-based data required for producers, users, processors, consumers, and tomato breeders to make informed choices amongst the varieties.

Materials and Methods

Sample collection: Three cultivars of tomatoes, namely Ibadan local (IbL), Ife and JM94/46 were obtained from the National Institute for Horticultural Research and Training (NIHORT), Ibadan, Nigeria and planted. The fruits were harvested, washed under running water and used for subsequent analysis.

Physico-chemical analyses of the tomato cultivars: The three varieties of tomatoes were analysed for moisture, pectin, vitamin C, total acidity, and soluble solids contents using standard methods.

Moisture content was determined by taking 5 g of sample placing onto previously dried, cooled and weighed moisture dish. The dish was covered and placed into the oven previously set at 100°C for 3 hrs. The samples were dried to a constant weight; the dish was transferred into a dessicator and allowed to cool before weighing again. Residue was recorded as total solids and loss in weight as moisture

$$\% \text{Moisture Content} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

To determine the pectin content, a portion of fifty gram each from blended sample was weighed into 800 ml beaker and 400 ml of water was added. It was boiled for 1hr, replacing the water lost by evaporation. Using a funnel, the content of the beaker was transferred to a 500 ml volumetric flask and made up to 500 ml volume at 20°C. It was properly shaken and filtered through No. 4 whatman filter paper into 500 ml Erlenmeyer flask, then 100 ml aliquot was pipetted into 800 ml beaker adding water and 10 ml of NaOH, stirring constantly, it was allowed to stand for 5 mins. Twenty-five ml of 1 N CaCl₂ solution was

added while stirring and allowed to stand for 1 hr. It was heated to boiling and allowed to boil for 1 min. It was filtered through whatman paper 4 that was already washed with hot water and oven-dried for 2 hrs at 100°C, cooled in a dessicator and weighed. The precipitate was washed with almost boiling water to wash off the chloride. It was tested for white precipitate with AgNO₃. The filter paper was dried overnight at 100°C, cooled in a dessicator and weighed. Total pectin was calculated as:

$$\% \text{ Calcium pectate} = \frac{\text{weight of Capectate} \times 100}{\text{weight of sample}}$$

Vitamin C content was determined as ascorbic acid by the 2,6-dichlorophenol indophenol titration procedure. Ascorbic acid was extracted using an acetic acid and metaphosphoric acid solution. The extracts were transferred with distilled water into a 50 ml volumetric flask and made up to the mark with more water and filtered rapidly. The filtrate was run from a burette into a test tube containing one drop of dilute acetic acid and 1ml of the redox dye, 2,6dichlorophenol indophenol solution. The volume of extract required to decolorize the dye was noted. The titration was repeated using standard ascorbic acid solution (1 mg pure vitamin per 100 ml) in place of the tomato extract. Ascorbic acid per 100g of tomato is calculated as:

$$\% \text{ Ascorbic acid} = \frac{w \times 100}{100}$$

w= vol of dye

Total acidity was determined by titration with 0.1 N NaOH until pH 8.1. Twenty-five gram of blended portion of each sample was taken and transferred to 200 ml of hot water in 400 ml beakers, boiled gently and filtered. Fifty ml of filterates were pipetted into 250 ml beakers and 100 ml of water was added to each of them. They were titrated to pH 8.1 using a pH meter. Total acidities were calculated as:

$$\% \text{ Total acidity} = \frac{1 \times \text{eqv. weight of acid} \times \text{N of NaOH} \times \text{titre}}{10 \times \text{weight of sample}}$$

Equivalent wt of acid (citric) = 70.0g

Total soluble solids were determined by placing 1 to 2 drops of tomato juice on the prism of the refractometer which was cleaned with distilled water and dried before use. The refractometer was standardized against distilled water (0° Brix TSS).

Minerals were determined using atomic absorption spectrophotometer (AAS- 969 Solar UNICAN) as outlined in AOAC International Methods of Analysis. Calcium was determined by accurately weighing 1 g of dried and ground sample into glazed, high-form porcelain crucible for 2 h in a muffle furnace at 500°C. The sample was allowed to cool and 10 drops of deionised water followed by 3 – 4 ml of nitric acid (HNO₃) were added to the sample. Excess nitric acid was evaporated by placing the sample on a hot plate set at 100 - 120°C. The sample was returned to furnace for additional 1h and after being cooled, the ash

was dissolved in 10 ml hydrochloric acid and transferred quantitatively to 50 ml volumetric acid. Lanthanum (10000 µg/ml) was added in all replicates and standards to obviate combined interference effects. For the determination of other minerals, the same procedure as outlined for calcium was followed. Potassium was partially ionized in the air-acetylene flame and to suppress ionization, cesium nitrate (1000 µg/ml cesium) was added in all the solutions including the blank. In case of high concentrations of potassium in all the samples, original samples were diluted in the range of 300-500 times in order to achieve the optimum working conditions for the instrument. Analyses of the minerals were carried out using atomic absorption spectroscopy set at different wavelengths for the optimum working conditions of the minerals.

Statistical Analysis: The data generated was analyzed with Statistical Package for Social Sciences (SPSS) software (Version 16.0) using analysis of variance (ANOVA) of mean values of replicate experiments and the level of significant differences was determined using Student NeumanKeuls (SNK) test.

Results and Discussion

Physico-chemical Analyses

The results (Table 1) showed that cultivar JM had the highest moisture content of 90-93 % at which was significantly different ($P < 0.05$) from IbL (90.15 ± 0.16) and Ife (90.6 ± 0.60). Soluble solids among the three cultivars were significantly different with highest in IbL at °Brix of 6.39 ± 0.12 , followed by Ife and JM. The values of total acidity was significantly different ($P < 0.05$) among the cultivars with IbL having the highest total acidity at $65.58 \pm 0.98\%$, followed by JM $49.0 \pm 0.16\%$ and Ife $25.14 \pm 0.16\%$. Pectin content and vitamin C content were not significantly different ($P > 0.05$) among the cultivars. The vitamin C content (48.34 ± 0.60) which is a function of the antioxidant activity was higher than that obtained by Nagamani (2017) which was (27.38mg). The pH values between 3.58 and 4.17 ± 0.03 recorded in these cultivars are lower than the values between 4.26 and 4.67 reported by Nagamani (2017). A lower pH value results in lower acidity level which can inhibit microbial activity thereby extending the storage stability of this varieties at 4.13 ± 0.12 and 3.55 ± 0.27 °Brix respectively.

The results (Table 1) shows the physico-chemical properties of the three cultivars in this study. Moisture content of 90-93 % as reported in this study is typical of most fleshy vegetables. Holland (1981) reported moisture content values of 93.1 % in tomato fruits, which is similar to that recorded in JM ($93.69 \pm 0.62\%$). The moisture content of fruits affects the chemical and physical aspects of food, which determine its freshness and storage stability. The soluble solids and total solids were significantly different among the three cultivars. The values for soluble solids of 4.13 and 6.39 °Brix in Ife and IbL are higher compared to the average value of 3.8 for the red-ripe tomato fruits reported by Willis et al. (1989). Tomato cultivars with higher soluble solids are preferred to reduce processing costs. The values of total acidity was significantly different ($P < 0.05$) among the cultivars with IbL

having the highest total acidity at $65.58 \pm 0.98\%$. Pectin content and vitamin C content were not significantly different ($P > 0.05$) among the cultivars. The vitamin C content (48.34 ± 0.60) which is a function of the antioxidant activity was higher than that obtained by Nagamani (2017) which was 27.38mg. The vitamin C content in these cultivars were generally higher than other reference varieties. The pH values between 3.58 and 4.17 ± 0.03 recorded in these cultivars are lower than the values between 4.26 and 4.67 reported by Nagamani (2017). A lower pH value results in lower acidity level which can inhibit microbial activity thereby extending the storage stability of this varieties.

Table 1: Physico-chemical properties of tomato cultivars

Parameter/Cultivar	IbL*	Ife*	JM94/46*
Moisture content (%)	90.15 ± 0.16^a	90.6 ± 0.60^a	93.69 ± 0.62^b
Pectin content (%)	0.43 ± 0.04^a	0.43 ± 0.08^a	0.42 ± 0.02^a
Soluble solids (°Brix)	6.39 ± 0.12^a	4.13 ± 0.12^b	3.55 ± 0.27^c
Refractive Index	1.36 ± 0.02^a	1.34 ± 0.03^a	1.34 ± 0.11^a
pH	3.58 ± 0.26^a	4.17 ± 0.03^b	3.71 ± 0.24^a
Total acidity (%)	65.58 ± 0.98^a	25.14 ± 0.16^b	49.0 ± 0.16^c
Vitamin C (mg/100g)	48.01 ± 0.07^a	47.97 ± 0.18^a	48.34 ± 0.60^a

*Values are means $\pm$ standard deviation

Values with same alphabet superscript in the same row are not significantly different ($P > 0.05$)

Minerals content of the tomato cultivars

The results of mineral content of the three cultivars are as presented in Table 2. There were significant differences ($P < 0.05$) in sodium and potassium among the three cultivars with the highest values recorded in Ife and IbL respectively. The potassium content in Ife (6.27 ± 0.06) and JM (6.12 ± 0.02) were not significantly different ($P > 0.05$). Iron was not detectable in IbL but was found in Ife and JM at 2.83 ± 0.08 and 4.45 ± 0.06 mg/100g each. The Mg and Ca contents (11 mg /100g and 13 mg /100g) were significantly higher than reported by Holland *et al.* (1991) i.e. 7mg /100g for Mg and Ca in tomatoes.

Table 2: Minerals content of the tomato cultivars

Mineral (mg/100g)	IbL*	Ife*	JM94/46*
Sodium (Na)	10.29±0.03 ^a	11.53±0.07 ^b	6.41±0.02 ^c
Potassium (K)	13.47±0.04 ^a	6.27±0.06 ^b	6.12±0.02 ^c
Phosphorus (P)	8.75±0.04 ^a	8.89±0.09 ^b	7.21±0.02 ^c
Zinc (Zn)	0.64±0.03 ^a	0.94±0.02 ^b	2.05±0.017 ^c
Manganese (Mn)	2.53±0.04 ^a	1.68±0.03 ^b	2.56±0.015 ^a
Copper (Cu)	1.32±0.04 ^a	1.08±0.02 ^b	3.15±0.02 ^c
Iron (Fe)	ND	2.83±0.08 ^a	4.45±0.06 ^b
Magnesium (Mg)	11.56±0.05 ^a	11.66±0.06 ^a	11.59±0.29 ^a
Calcium (Ca)	13.43±0.04 ^a	14.84±0.06 ^b	13.32±0.08 ^a
Cadmium (Cd)	ND	ND	ND
Lead (Pb)	1.22±0.13 ^a	ND	0.05±0.02 ^b
Chromium (Cr)	ND	ND	ND

*Values are Means± S.D; ND – Not detectable

Values with same alphabet superscript in the same row are not significantly different (P > 0.05)

Fe was below detectable limits in IbL; Holland *et al* (1991) reported the value of 0.5 mg/100g of Fe in tomatoes. The Fe content in Ife and JM cultivars were significantly different (P≤ 0.05). The Na, K, P, Zn, and Cu contents were significantly different (P≤ 0.05) in all three cultivars. There were no significant differences (P≥0.05) in the Ca and Mn content between IbL and JM; and the Mg content in all three cultivars were not significantly different (P≥0.05). Chromium (Cr) were not detectable in all cultivars. Cadmium was not detected; lead was however detected in IbL and JM at 1.22±0.13 and 0.05±0.02 mg/100g respectively. The presence of heavy metals could be as a result of contamination from extraneous sources. A concentration of 0.05 mM Cd in the soil or nutrient solution is high enough to induce toxicity symptoms in tomato (Ouaritiet *al.*, 1997).

Conclusions

This study revealed that there are differences and similarities in the physico-chemical and mineral composition of the three local cultivars investigated. The information generated from this study can provide a basis for the selection of appropriate cultivars to suit market trends, consumer and culinary preferences. It can also support the selection of genotypes for a successful tomato breeding project, which is closely linked to adequate knowledge of the market and consumer requirements on one hand and also of the preferences of processors and growers regarding the overall quality of the candidate genotypes.

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INFLUENCE OF TEMPERATURE ON THE OXIDATIVE TENDENCY OF SESAME SEED OIL-BASED MAYONNAISE

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Abstract

The influence of varied temperatures on the oxidative stability tendencies of mayonnaise produced from sesame seed oil was investigated. Mayonnaise was prepared from cold-pressed sesame oil (control sample) as well as sesame oil expressed from 55°C, 60°C, 65°C and 70 °C. The prepared mayonnaise was analyzed for peroxide value, iodine value and acid value. The result obtained were subjected to statistical analysis using Analysis of Variance (ANOVA). The peroxide value of the samples increased with increase in expression temperature and the mayonnaise prepared from hot pressed oil showed no significant difference in peroxide value. The iodine value ranged from 40.1g/100g for sample prepared from oil expressed at 70°C to 44.8g/100g for the control sample. The iodine value of the samples prepared with hot pressed oil showed no significant difference with the cold pressed except for sample prepared from oil expressed at 70°C but was significantly higher than that of the control sample. While the peroxide value of the samples was within range of recommended values, the acid value was higher than the recommended values. It was concluded that the prepared mayonnaise are less susceptible to rancidity and are expected to have good keeping quality.

Key words: Peroxide value, Iodine value, Mayonnaise, Sesame oil

Introduction

The global trend in food consumption pattern is aimed at pursuing wellbeing and health. This demand for therapeutic foods has generated interest in healthy and functional oils which can find application in modern food systems. Vegetable oils play an important role in modern food systems, especially in the development of food emulsions and emulsion-based edible films and coatings. In recent years, there has been a considerable interest in the potential health benefit of vegetable oils from seeds such as olive seed, soybean, flaxseed, sunflower seed, sesame seed etc., especially regarding their role in cardiovascular health and cancer. This interest in vegetable oils relates to the nature of their fatty acids, their functional properties, flavonoids, possible cholesterol lowering compounds and antioxidant activities. Sesame seed oil is rich in oleic and linoleic acids which is responsible for its anti-bacterial and anti-inflammatory properties. The oil has 85% total fatty acids which underscores its effectiveness in reducing blood cholesterol levels (Lichtenstein and Deckelbaum, 2001). Mayonnaise is essentially an oil-in-water emulsion prepared from vegetable oils, mustard seed flour, vinegar and egg yolk, with other minor ingredients added for flavoring, they are one of the most popular and widely used sauces in the world, especially in confectionaries as salad dressing.

The mechanism of lipid oxidation and deterioration in food emulsions such as mayonnaise,

is complex and not fully understood as most studies of oxidation have been performed on bulk oil or in simple model systems (Thomsen *et al*, 2000). Oil-in-water emulsions such as mayonnaise contain at least an aqueous phase, the oil phase, and the oil-water interface. In emulsions, oxidation may be initiated in any of these three phases (Thomsen *et al*, 2000). Lipid oxidation in mayonnaise is one of the reasons for quality deterioration in oil rich food products, due to the unsaturated character of the oil. The levels of peroxides and iodine in fats and oils have been extensively reported in literatures. The peroxide value is still the most common chemical method of measuring oxidative deterioration of oils. Although hydroperoxides decompose to a mixture of volatile and non-volatile products and they also react further to endoperoxides and other products, the peroxide value measurement is a useful method of monitoring oxidative deterioration of oils. While there are considerable data on the effect of hot expression on the peroxide value of oil from oil bearing seeds, mayonnaise could be expected to behave differently from simple fats and oils since it is a formulated emulsion. This study examines the oxidative tendency of sesame seed oil-based mayonnaise.

Materials and Method

Sesame seeds used in this experiment were obtained from an open market in Ilorin, Kwara State, Nigeria. The sesame seeds were sorted and cleaned to remove stones and other foreign materials. Oil was mechanically expressed from the sesame seed at different temperatures 55°C, 60°C, 65°C and 70°C while oil expressed at ambient temperature was used as control. The ingredients for mayonnaise production were obtained from an open market in Ilorin, Kwara State while all chemicals used for analyses were of analytical grade. Mayonnaise was prepared using method described by the Patent European Application (1999). Physicochemical analysis was carried out on the mayonnaise samples. The samples were analyzed for peroxide value, iodine value and acid value. Samples were analyzed using procedure described by AOAC, (2008). The results obtained were subjected to statistical analysis using Analysis of Variance (ANOVA) in a statistical package for social sciences (SPSS) version 22.

Results and Discussion

Table 1. Physicochemical Composition of the Mayonnaise Sample

Sample	Peroxide Value (meq/kg)	Iodine Value (g/100g)	Acid Value (%)
CP	1.90 ^a ±0.05	44.8 ^b ±0.02	3.87 ^a ±0.02
HPT55	1.97 ^{ab} ±0.02	43.9 ^b ±0.03	3.90 ^a ±0.05
HPT60	2.20 ^b ±0.00	43.1 ^b ±0.02	3.98 ^{ab} ±0.00
HPT65	2.38 ^b ±0.02	42.8 ^b ±0.03	4.00 ^b ±0.03
HPT70	2.43 ^b ±0.05	40.1 ^a ±0.05	4.03 ^b ±0.75

Values are means ± standard

deviation of triplicate experiment. Values in the same column with different superscript are significantly different ($p < 0.05$). **CP** – Cold Press (control sample) expressed at ambient temperature, **HPT55** – expressed at 55 °C, **HPT60**– expressed at 60 °C, **HPT65**– expressed at 65 °C, **HPT70**– expressed at 70 °C

The result of the peroxide value is presented in Table 1. The result shows that the peroxide value increased with increase in expression temperature. The peroxide value ranged from 1.90meq/kg for the control sample to 2.43meq/kg for sample HPT70 prepared from oil expressed at 70°C. The peroxide value of the control sample showed no significant difference with the HPT55 prepared from oil expressed at 55°C but was significantly lower than other samples under study. Peroxide value is used to determine the amount of oxidized oil in a food product. Peroxide is among the primary products of oxidation. High values of peroxide in edible oils suggests onset of oil oxidation and undesirable quality. This increase in the peroxide value of the samples may have resulted from the increase in the expression temperature of the oil used in the mayonnaise preparation. In principle, the rate of oxidation increases exponentially with an increase in temperature, although the effect of temperature is complicated by a reduction in oxygen solubility in liquids, especially at high temperature and by changes in partitioning of antioxidants between phases if more than one phase is present. This rate-limiting step in the autoxidation pathway have been reported to change significantly with an increase in temperature in the absence of antioxidants. Irwin and Hedges (2004) reported that for a sunflower oil-in-water emulsion from which tocopherols had been removed, the time to attain peroxide value of 50meq/kg decreased from 8 days at 30°C to 3 days at 50°C. It is possible that the inherent antioxidants in the expressed sesame oil may have limited the expected exponential formation of hydroperoxides in the oil, resulting in the insignificant difference in the peroxide value of the mayonnaise under study. It is also possible that the insignificant difference observed in the peroxide value of the mayonnaise prepared with sesame oil expressed at higher temperatures resulted from the breakdown of primary oxidation products including hydro peroxide into smaller stable fragments, such as carbonyl compounds, alcohols and hydrocarbons in the oil used in the preparation of the mayonnaise. This insignificant difference observed in the peroxide value may imply that the mayonnaise prepared with sesame seed oil, mechanically expressed at higher temperatures may not be more vulnerable to oxidative rancidity than each other. The peroxide value of the samples under study were below 10meq/kg limit recommended by the Malawi standard for mayonnaise specification (2021). According to the Malawi standard, mayonnaise with peroxide value above 10meq/kg is considered rancid. Pradhananga and Adhikari (2015) reported a similar peroxide value of 1.12meq/kg obtained from mayonnaise produced from skim milk powder. Ahmadi-Dastgerdiet *al.* (2019) also reported similar value of 2.97meq/kg for mayonnaise prepared from soya oil

The result of the iodine value of the mayonnaise samples are also presented in table 1. The result showed that iodine value ranged from 40.1g/100g for sample HPT70 to 44.8g/100g for the control sample. The result also showed that the iodine value of the control sample showed no significant difference with other samples prepared with oil under hot expression except for sample HPT70 prepared with oil expressed at 70°C. Iodine value is an indication

of the degree of unsaturation in fats and oils and is a measure of vulnerability to the oxidation. Iodine value is the amount of Iodine that can react with oil or fat of a common mass (usually 100 grams). This indicates the degree of unsaturation of fats. The saturated fat takes up very little or no Iodine, so their iodine value is considered to be of value zero. But the unsaturated fats have double or triple bonds which are generally very reactive towards the iodine. The more the double or triple bonds of the carbon atom in oil, the reactivity with iodine increases, consuming more iodine in reaction, thus resulting in a higher iodine value. Unsaturated fats/oils are known to be more unstable and susceptible to oxidation than the already oxidized and saturated counterparts. The higher the iodine value of the samples, the more susceptible the samples are to oxidation. This corroborates the result of the peroxide value in the samples under study. Onwuzuruike *et al.* (2022) reported a much lower value (28.7g/100g) of iodine for mayonnaise prepared from African pear oil chemically extracted using Soxhlet extraction method but a much higher value (78.85g/100g) for mayonnaise prepared from soybean oil obtained from an open market. The results also showed that the samples prepared from oil under hot expression did not show any significant difference in their iodine value. This suggests that mayonnaise prepared with hot pressed vegetable oil may be more unstable under storage and have higher vulnerability to oxidative rancidity when compared with mayonnaise prepared from cold pressed vegetable oil.

Acidity is an index which helps us to identify any rancidity in oils and fats. Acidity of oils and fats is mostly measured on the basis of acetic acid. Acid value of the samples under study is shown in table 1. The acid value ranged from 3.87 for the control sample to 4.03 for sample HPT70. The result further showed that the acid value increased with increase in expression temperature. The increase in acid value as the temperature increases could be attributed to high degree of unsaturation of the oils at higher temperatures of expression used in the preparation of the mayonnaise samples. The values obtained in this study are higher than the recommended values of 0.3 – 1.5 for mayonnaise (Malawi standard for mayonnaise specification, 2021)

Conclusions

The study revealed the oxidative tendency of mayonnaise produced from sesame seed oil. The study showed that the peroxide value of the samples increased with increase in expression temperature. The study also showed that the peroxide values of the mayonnaise prepared from hot pressed oil showed no significant difference. The iodine value of the control sample showed no significant difference with that of samples prepared with hot pressed oil except sample prepared with oil expressed at 70°C. The study also revealed that while the peroxide value of the samples was within range of recommended values, the acid value was higher than the recommended values. It is thus concluded that the prepared mayonnaise are less susceptible to rancidity and are expected to have good keeping quality.

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TRADITIONAL USES OF COCOYAM IN SOME NIGERIAN STATES: A SURVEY

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ABSTRACT

The study undertook to ascertain the traditional uses of cocoyams through a survey. The survey revealed that there are five edible varieties known traditionally and these include *Colocasia esculenta*, *Xanthosomasagittifolium* variety, *Crytospermachamissonis*, *Alocasia* specie and Giant *Xanthosomasagittifolium* varieties. The respondents agreed at different levels as per the usage of traditional foods from these cocoyam varieties. One hundred percent of the respondents agreed that “achichaede” and soup thickener were produced from cocoyam while 95.73% agreed that cocoyam was also used for *fufu* production. Over 50% of the respondents are knowledgeable of the use of cocoyam leaves in foods. Nigerians should be sensitized unto more consumption of our traditional cocoyam food products. This will reduce importation and use of exotic foods reduce the consequent foreign exchange challenges, and enable the use of our indigenous foods.

Keyword: Cocoyam *fufu*, “Achichaede”, Soupthickner, roasted cocoyam, cocoyam chips

INTRODUCTION

Cocoyams are edible aroids, mainly grown for food and they belong to the *Aracea* family. They comprise of many underground food crops grown in several tropical and sub-tropical countries, (FAO, 2003) and are characterized morphologically by subterranean stems and corms, enclosed by dry scale-like leaves. Cocoyams are the sixth most important root and tuber crop world-wide and are highly produced in Africa, tropical and sub-tropics, notably Nigeria, Ghana and Cameroon, contributing to 60% of the total African production. Thus, cocoyams are important to regional food security, but are underutilized (Boakye *et al.*, 2018). Cocoyams contain an irritant said to be calcium oxalate (Oyebode *et al.* 2011). This crystal causes scratchiness in the throat when cocoyams are eaten raw or when improperly cooked. Oxalate has been reported to cause kidney stones (Oyebode *et al.*, 2011; Falade and Okafor, 2015). Cocoyams are also laden with anti-nutritional compounds which generally decrease the absorption of nutrients after digestion. Among the known edible cocoyam cultivars are *Taro*, *Tannia* and Indian cocoyam also called cocoindia, giant tannia and upland giant taro. These are scientifically known as *Colocasia esculenta* for taro, *Xanthosomasagittifolium* for tannia and *Crytospermachamissonis* for cocoindia, respectively (Okeke *et al.*, 2008). *Alocasia spp* and giant *X. sagittifolium* (Fig 1) are believed to be lesser known to a large extent. Nguimbou *et al.* (2014), reported *Alocasia macrorrhiza* (giant taro) as (Hawaiian, American or New World) Taro which are grown on dry land. Cocoyam especially Taro and Tannia are said to be giant crops because their corms, cormels, leaves, stalks and inflorescence are all utilized for human consumption, (Chukwu *et al.*, 2008). Cocoyam like yams, suffers from extensive post-harvest

losses since it is stored as fresh corms. Urban migration has aided the scarce knowledge about this traditional food crop, since more processed exotic foods prevail in the cities than do the traditional foods. Much as Nigeria is one of the largest producers of cocoyam and, cocoyam ranks third in the order of importance after cassava and yams among roots crops in the traditional food systems, the crop remains underutilized. Cocoyam could serve as a natural locus for improving food and nutrition security of the rural and urban dwellers in Nigeria. Since cocoyam, like yam and cassava are first consumed in the areas where they are grown as traditional dietary staples, it is therefore, necessary to document the traditional cocoyam species, the food products from them, and, their uses. These will among others expose their relevant research needs. This study therefore is designed to document the local names and uses of cocoyam based traditional foods, by survey.

MATERIALS AND METHODS

Study area: The study was done at Oraifite, Umunze, Oko and Ekwulobia, all of which are rural areas in Anambra State, and, Enugu, an urban city in Enugu State. Comparatively, respondents from non-Igbo states were more available in Enugu than in the named towns in Anambra state.

Methods of data collection

Well-designed questionnaire was issued to groups of women in various gatherings including households, women meetings and in the markets. The questionnaire had questions on two parts viz, parts A and B. Part A covered the individuals' documentation including on age group and whether domiciled in rural or urban areas. Part B had questions to elicit list of cocoyam types and local names, their uses evidenced by the traditional cocoyam foods. Fully answered questionnaires were gathered from 117 respondents and analyzed. Results were presented on Table 1, which revealed local names and uses of the cocoyams, and necessary information from literature were provided.

RESULTS AND DISCUSSIONS

Table 1: Indigenous food names and uses of cocoyam in Nigeria

The indigenous names and food uses of different parts of cocoyams are presented below:

Part of Plant	Name of Product	Method of preparation and uses	Local names and References	Improved product for convenience
From <i>C. esculenta</i>				
Cormels	Soup Thickener <i>C. esculenta</i>	Cleaned, washed (peeled or unpeeled), boiled until soft, peeled, pounded into a dough, put into the soup while still on fire to gel and thicken the soup.	Hausa: <i>Namijigwaza</i> Igbo: <i>Ede ofe</i> Yoruba: <i>Koko</i>	Cormels are now peeled and the sun-dried slices are floured. The flours are used for soup thickening.
Corms or	<i>Achichaede</i> <i>C. esculenta</i>	(1) Cleaned, boiled overnight	Hausa: <i>Namijigwaza</i> Igbo: <i>Ede ofe</i>	Consumers' size-reduce the " <i>achicha-edé</i> "

Cormels		(for upwards of 3h). Peeled, sliced and eaten with salted palm oil or seasoned palm oil. A traditional emulsion produced by mixing palm oil with trona (as emulsifier) then <i>Ogiri</i> condiment can also be used as the sauce. (2) Dried <i>achicha</i> chips: size reduced, re-hydrated, steamed and mixed with cooked leguminous seeds such as pigeon peas, rice bean or <i>Kresingellageocarpa</i> and palm oil, salt and spiced and eaten.	Yoruba: <i>Koko</i> Nzulu (2007) Nzulu (2021)	dried/ chips using commercial mills. The further size reduced product is stored thus, reducing the stress of size reducing manually as many as they would need to prepare the processed product.

From *X. sagittifolium*

Corms or Cormels	<i>Fufu</i> <i>X. sagittifolium</i>	Unpeeled, washed, boiled until cooked, then peeled and pounded into cocoyam <i>fufu</i> dough, then swallowed in small balls with soup or stew	Hausa: <i>Namatagwaza</i> Igbo: <i>Ede eko</i> Yoruba: <i>Kokoroisu</i>	None yet (NY)
Cormels	Fried Chips/Crisps <i>X. sagittifolium</i>	Washed, peeled, sliced and fried in hot vegetable oil.		None yet (NY)
Cormels	Ikokore (cocoyam pudding) <i>X. sagittifolium</i>	Peeled, washed, grated into a mash and, spiced with salt and condiments. The mash is cut into small pieces and boiled with little water for about 20min. The heat is then lowered and smoked fish, shrimps, preferred cooking oil, salt or stock e.g., <i>maggi</i> are added. With about 10min simmering, the content of the pot is mixed using spoon. Ikokore (pudding) could be served hot.	Kayodeet <i>al.</i> (2003) Kayodeet <i>al.</i> (2006) Olayiwolaet <i>al.</i> (2013)	<i>X. sagittifolium</i> Flours can be used for the same product
Cormels	Roasted Cocoyam <i>X. sagittifolium</i>	<i>X. sagittifolium</i> is roasted (like yam) then eaten with palm oil spiced with onions and fermented <i>Pentaclethra macrophylla</i> , slices.	Nzulu(2010)	None

Cormels	Ikpankwukwo pudding <i>X. sagittifolium</i> and <i>D. alata</i>	Scoops of peeled, washed, grated <i>tannia</i> mash, are enclosed in fluted pumpkin leaves then dropped in oiled pots and steamed for about 30mins with little water addition. Salt and spices are added. All (the gelled material and the other ingredients) in the pot are mixed and the product is consumed.	Kayode <i>et al.</i> (2006) Nzelu(2007) Nzelu(2010)	
Corms or Cormels	Aniga gelled product <i>X. sagittifolium</i>	Mash from washed, peeled and grated <i>X. sagittifolium</i> and <i>D. alata</i> with or without <i>Dioscorea bulbifera</i> are mixed homogenously, wrapped with wilted plantain/ banana leaves and cooked overnight. The gelled product is later consumed using spiced palm oil or “ <i>ncha</i> ” a palm oil-in-water emulsion spiced with “ <i>ogiri</i> ” condiment.	Nzelu(2010)	None
From <i>C. chamissonis</i>				
Corms or Cormels	“Fufu” <i>C. chamissonis</i>	Unpeeled, washed, boiled until cooked, then peeled and pounded into cocoyam <i>fufu</i> dough, then swallowed in small balls with soup or stew.		None
Corms or Cormels	<i>Achichaede</i> From Indian cocoyam	Dry cleaned, washed and possibly sliced large corms and, cormels of Indian cocoyams are boiled overnight. The change in colour of the pulp from white to shade of brown to pinkish brown, confirms the doneness of the “ <i>achicha-edé</i> ” product. The “ <i>achicha-edé</i> ” is then peeled and consumed after dipping in salted palm oil, or salted palm oil garnished with fresh pepper and <i>Congronemalatifolium</i> “ <i>utazí</i> ”		Like every other “ <i>achicha-edé</i> ” from other cocoyam species, the sun dried “ <i>achicha-edé</i> ” products can be further size-reduced, soaked, grated and mixed with boiled leguminous seeds or boiled edible leafy vegetables and later mixed into porridge, then consumed.

		leaves. “Ncha” sauce can also be used as the compliment for the “ <i>achicha-edè</i> ”.	
From <i>Alocasiaspp</i>			
Corms or Cormels	“Fufu” <i>Alocasiaspp</i>	Unpeeled, washed, boiled until cooked, then peeled and pounded into cocoyam <i>fufu</i> dough, then swallowed small balls with soup or stew.	Hausa: NA Igbo: <i>Ede mwine</i> ; <i>Akonoke, Ogafereoke</i> Yoruba: <i>Kokoroisu</i>
	<i>Achichaede</i> from <i>Alocasiaspp</i>	Dry cleaned, washed and possibly sliced large corms and, cormels of <i>Alocasiaspp</i> cocoyams are boiled overnight. The change in colour of the pulp from white to shade of brown to pinkish brown confirms the doneness of the “ <i>achicha-edè</i> ” product. The “ <i>achicha-edè</i> ” is then peeled, sliced and consumed after dipping in salted palm oil, with or without garnishing with fresh pepper and <i>Congronemalatifolium</i> “ <i>utazɪ</i> ” leaves. “Ncha” sauce can also be used as the compliment for the “ <i>achicha-edè</i> ”.	Like every other “ <i>achicha-edè</i> ” from other cocoyam species, the sun dried “ <i>achicha-edè</i> ” products can be further size-reduced, soaked, reheated and mixed with boiled leguminous seeds and later mixed into porridge, then consumed.
From Giant <i>X. sagittifolium</i>			
Corms with or without Cormels	“Fufu”	Cleaned, unpeeled, compulsorily sliced, giant <i>X. sagittifolium</i> corms are boiled till the pulp gets soft and poundable. The slices are then peeled and pounded to produce the “ <i>fufu</i> ”. Small balls of the <i>fufu</i> are moulded then dipped in stew or soup and consumed by swallowing.	
	<i>Achichaede</i> from <i>Giant X. sagittifolium</i>	Dry cleaned, washed and compulsorily sliced, <i>Giant X. sagittifolium</i> are boiled overnight. The change in colour from light yellow to shades of brown to grayish pink	Like every other “ <i>achicha-edè</i> ” from other cocoyam species, the sun dried “ <i>achicha-edè</i> ” products can be further size-reduced, soaked,

confirms its doneness. The “achicha-edē” is then peeled, sliced and consumed with salted palm oil with or without garnishing with “utaẓi” leaves. “Ncha” sauce can also be used as a compliment for the “achicha-edē”.	reheated and mixed with boiled leguminous seeds and later mixed into porridge, then consumed.

Key: NA = Not available at the time of writing

Table 1 showed the indigenous food uses of different species of edible cocoyam accessed from *C. esculenta*, *X. sagittifolium*, *C. chamissonis*, *Alocasia*spp and *Giant X. sagittifolium*. The major food uses from these cocoyam species included soup thickening, roasted and fried chips from *X. sagittifolium*, then *fufu* and “achicha-edē” products. Ninety five percent (95%) of the 117 who were from Anambra, Abia, Ebonyi, Enugu and Imo states gave the local names and the traditional food products as well (Table 1). However, all the respondents were knowledgeable about the use of *C. esculenta* in soup thickening. From the survey, the respondents agreed that cocoyams are used for various food purposes, but the specific cocoyam uses depended on the cocoyam variety. One hundred and twelve (112) of the 117 (95.73%) of the returned questionnaire agreed that the corms of every edible cocoyam is used for *fufu* production, with or without mixing with cassava or yam *fufu*. Nzelu(2007) attested to the use of corms in the production of cocoyam *fufu* and also reported that the cormels of *C. esculenta* variety is used for the production of “*Uliedē*”, soup thickener. Furthermore, these authors reported that cocoyam flours for soup thickening were also produced from cocoyam cormels. These 95.73% of the respondents were above 50yr age groups. Hundred percent (100%) of the respondents agreed that cocoyams are used for the production of “*achicha-edē*”, reporting that consumption of “*achicha-edē*” alone or in combination of *achicha* and leguminous seeds particularly “*fiofio*” was more popular. Eighty percent (80%) of the respondents agreed that the cormels of *X.sagittifolium* were eaten traditionally after roasting in the open fire or peeled, sliced and fried in vegetable oil into cocoyam chips. Table 1 showed more information on the uses of cocoyams.



Fig 1: cocoyam species used in traditional foods

CONCLUSION

The study has shown that the traditional food uses of cocoyams included the production of

cocoyam *fufu* from the corms of every edible cocoyam variety, the production of soup thickener from the *C. esculenta* cormels and the production of roasted and fried cocoyam chips from the cormels of *X. sagittifolium* variety. Every cocoyam corm is used for “*achicha-edede*” production, part of the “*achicha-edede*” is sun-dried, and the dried chips is used later. Also the tender leaves and inflorescence of *X. sagittifolium* were used as leafy vegetables.

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PHYSICOCHEMICAL AND SENSORY PROPERTIES OF JAMS PREPARED FROM RED BELL PEPPER

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Abstract

Red bell pepper is a good source of minerals and vitamins with a lot of health benefits, but they are highly perishable due to high moisture content. Therefore, this study processed the two commonly consumed varieties of red bell pepper in Nigeria (Yoruba and Hausa) into jam. Fresh red bell peppers were sorted, separated from the stems, washed, sliced (5 mm), homogenized with water (1:1 w/w, 5 min), heated (70 °C for 10 minutes), ingredients were added, then evaporated. Analyses were carried out on the red bell pepper and jam samples. The average length, width and mass were (6.79 cm, 2.57 cm and 16.82 g) and (6.78 cm, 2.2 cm, and 31.38 g), for Yoruba and Hausa variety. The pH, total soluble solid, titratable acidity, β -carotene, vitamin C, phenolic, flavonoid and DPPH were 6.38, 12.80, 16.44, 5.14, 115.44, 92.84, 65.1642.07 and 5.94, 10.70 °brix, 15.80 g/100 g, 6.57 μ g/g, 102.02 mg/100 g, 84.60 mg/100 g, 62.01 mg QE/100g, 33.88 for Yoruba and Hausa variety. This research indicates that nutritious and functional jam samples with acceptable sensory attributes can be produced from locally grown red bell pepper.

Keywords: Red bell pepper, jam, variety, antioxidative, functional

Introduction

Red bell pepper (*Capsicum annum* L.) is a fruit well known for its high content in bioactive compounds and strong antioxidant capacity (Chavez-Mendoza *et al.*, 2015). It is among the most popular fresh vegetables worldwide due to its combination of colour, flavour, and nutritional value (Anaya-Esparza *et al.*, 2021). Red bell pepper is one of the mostly produced vegetables around the world consumed both as fresh vegetable, as spice for their characteristic red colour and sometimes for its pungency (Shama *et al.*, 2015; Tripodi and Kumar, 2019). Pepper consumption is gaining popularity due to the fact that they are cholesterol free, low in sodium and calories. Red bell pepper is a good source of vitamins A and C, possess antimicrobial activity and reduces the risk of life-style

related diseases such as arthritis, cancer, diabetes and CVDs (Zhang *et al.*, 2015).

Fresh red bell pepper has exceptionally high quantities of ascorbic acid and attractive red colour which is due to several carotenoid pigments such as β -carotene with pro-vitamin A activity and oxygenated carotenoids such as capsanthin, capsorubin, and cryptocapsin (Deepa *et al.*, 2006; Arimboore *et al.*, 2015). These bioactive compounds have been proven to be effective against scavenging free radicals. Red bell pepper contains large quantities of neutral phenolic compounds or flavonoids which provide beneficial effects in human health due to their antioxidant properties (Amit *et al.*, 2021). It protects against the oxidative damage to cells and thus prevents the development of common degenerative diseases such as cancer, cardiovascular diseases, cataracts, diabetes, Alzheimer and Parkinson (Imran *et al.*, 2018; Correa *et al.*, 2018; Mohamed *et al.*, 2019). They also promote optimal health, lung health and better eyesight (Nadema *et al.*, 2014). Despite all these nutritional and health benefits they are highly perishable due to high moisture content which reduces the market value and hence result into high shortage for the farmer and thus increase in environmental pollution,

Jam is a fruit preserve with a stable shelf-life that depends on high sugar content (68-72%) combined with fruit acidity that prevents microbial invasion and growth. Jam with good quality requires precise balance between sugar level, acidity and pectin content of fruit boiled together to produce a gel on cooling (Egan *et al.*, 2001). They tend to hold their shape, but are generally less firm than jellies (Barbara, 2008). Availability of fruits is seasonal and therefore, jam production from fruits helps the availability of fruits at off-seasons. Jam enjoys substantial shelf life and thus can be made available round the year. The objective of the study was to determine the physicochemical and sensory properties of jams prepared from two varieties of fresh red bell

Material

Two commonly consumed varieties of Fresh red bell pepper fruit were procured locally and identified at Botany Department LAUTECH, while sucrose, citric acid, pectin and sorbitol, were obtained from a standard laboratory in Ibadan, Oyo State, Nigeria. Other ingredients such as honey and sugar were obtained from a standard supermarket in Ibadan. All reagents used were of analytical grade.

2.2 Methods

2.2.1 Production of Jam

Jam was produced as described by Felipe *et al.* (2009) as shown in Fig 3.1. Fresh red bell peppers were sorted, separated from the stems, washed, weighed, ground and homogenized with water (1:1 w/w) for about five (5) minute in a food-processor (Kenwood Food Processor model FP120). The homogenized pulp was heated in an aluminum pan at 70 °C for 10 minutes under direct fire to concentrate the aqueous extraction of pepper solids. The biggest solids were then removed by means of a plastic sieve. The °Brix of the juice was determined using a refractometer (Bellingham, Stanley Eclipse Hand Held Refractometer). Sucrose was mixed with the diluted juice and the solution was transferred to an aluminum pot and evaporated at atmospheric pressure (91.325 Pa) under direct fire. The pH was

measured and adjusted with citric acid until it reached a value within the range recommended (3.2-3.4). sugar, honey and sorbitol were used for the sweetening of the Jam. The jam was hot filled at 104 °C The formulations used for the jam production is as shown in Table 1.

2.3 Chemical analysis

The fresh peppers were characterized by determining the length, diameter and mass of the pepper. The length and the breadth were measured using Vernier caliper (Electronic Digital Caliper Vernier - 150MM LCD) while the mass was determined using weighing balance (High precision electronic balance platform digital scale, weighing scale.Model: dj-320a). The total Soluble solids (SS) was determined with the aid of a refractometer by direct reading in °Brix (AOAC, 2010). The pH of the macerated red bell pepper was determined using pH meter (Jenway 3505). The total titratable acidity was determined by using phenolphthalein, expressed as a percentage of citric acid(Corrêa *et al.*, 2018).B- carotene was determined as described by Chávez-Mendoza *et al.* (2015).The vitamin C contents of the fresh red bell pepper were determined by titration as described by Nerdy (2018). The fresh red bell pepper sample was grounded, sieved and the liquid extract was used for determination of phenolic compound using the colorimetric method of Folin-Denis.Gallic acid was chosen as a standard. The calculation of total phenol content was based on the calibration curve of the gallic acid standard and the data was expressed as milligram gallic acid equivalents (GAE) 100 g⁻¹ fresh weight. Total flavonoids were determined as described by Lee *et al.* (2013). Total flavonoids were expressed as mg catechin equivalents (CE)/100 g sample.The DPPH scavenging activity of the red bell pepper was carried out by the method of Onwuka (2005).

2.4 Sensory evaluation

Jam samples were subjected to sensory evaluation using 50 semi-trained panelists. The jam was served with random coded plates. It was also rated on a 9 point Hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely) for different sensory attributes (colour, aroma, firmness,gelatinous, taste, mouth feel, overall acceptability)

4. Results and Discussion

The average values obtained for the length, diameter and weight of the Yoruba red bell pepper were 6.79 cm, 2.57 cm and 16.82 g, respectively, while that of the Hausa red bell pepper were 6.78 cm, 2.2 cm, and 31.38 g, respectively.The result of the physico-chemical analysis is as shown in Table 1. The pH values of both peppers were 6.38 and 5.94, respectively, indicating that both varieties of pepper are low acidic fruits, since fruits having pH higher than 4.6 are classified as low acidic substances (McGlynn 2016). Mohamed *et al.* (2017) reported 4.8, Corrêa *et al.* (2018), reported 5.65 to 5.84 for varieties of red bell pepper. This also means that the Yoruba variety is more alkaline than the Hausa variety. The total

soluble solids and titrable acidity were (12.80 and 16.44) and (10.70 and 15.80) for Yoruba and Hausa variety. The TSS/acidity ratio is the main analytical measurement for quality in juice production (Mohamed *et al.*, 2017). The bigger the ratio, the better the juice flavor. This indicates that fresh red bell pepper can be processed into accepted quality juice. The beta carotene of Yoruba and Hausa variety were 5.14 and 6.57 microg/g. The form of vitamin A that orange and red peppers contain is called beta carotene, which the body converts into the active form of vitamin A. Beta carotene is what gives these peppers their orange and red colours. This is important for good sight and general immunity of the body. Vitamin C contents were 115.44 and 102.01 mg/ 100 g. Total phenol content were 92.84 and 84.60 mg/100 g while total flavonoids were 65.16 and 62.01 mg QE/100g. The DPPH were 42.07 and 33.88% for Yoruba and Hausa variety. The values are within the range reported by other researchers for red bell pepper (Yazdizadeh *et al.*, 2013; Arimboore *et al.*, 2015; Mennat *et al.*, 2019). The sensory evaluation result indicated that all the jam blends was acceptable to the panelist as shown in Table 2.

Conclusion

This study has shown the potentials of producing functional and acceptable jam samples from red bell pepper (*Capsicum annuum*). This will improve the economic potentials of the red bell pepper and hence improve the economy of Nigeria.

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Table 1: Physico-chemical properties of red bell pepper

Parameters	A	B
pH	6.38	5.94
Total soluble solids °brix	12.80	10.70
Total titrable acidity g/100 g	16.44	15.80
TSS/acidity ratio	0.053	0.68
β-carotene	5.14	6.57
Vitamin C (mg per 100 g)s	115.44	102.01
Total phenols (mg/100 g)	92.84	84.60
Total flavonoids (mg QE/100g)	65.16	62.01
DPPH (%)	42.07	33,88

A= Yoruba Red bell pepper

B= Hausa red bell pepper jam

Table 2: Sensory attributes of red bell jam samples

Sample /parameters	Colour	Aroma	Firmness	Gelatinous	Taste	Mouth feel	Overall acceptability
A	8.18±0.85 ^a	7.78±0.84 ^a	7.90±1.11 ^b	7.46±1.25 ^a	8.12±1.00 ^b	7.98±0.89 ^b	8.34±0.71 ^b
B	7.80±0.73 ^a	7.44±1.01 ^a	7.64±1.10 ^{ab}	7.36±1.36 ^a	7.54±1.50 ^a	7.28±1.35 ^a	7.76±1.06 ^a
C	7.88±0.90 ^a	7.40±1.11 ^a	7.68±1.09 ^{ab}	7.40±1.05 ^a	7.44±1.54 ^a	7.38±1.34 ^a	7.62±1.12 ^a
D	8.04±0.88 ^a	7.50±1.15 ^a	7.38±1.03 ^{ab}	7.56±1.18 ^a	7.54±1.25 ^a	7.52±1.03 ^{ab}	7.76±1.09 ^a
E	7.98±0.86 ^a	7.60±0.83 ^a	7.72±0.99 ^a	7.94±0.86 ^{ab}	7.54±1.01 ^a	7.54±1.26 ^{ab}	7.82±1.06 ^a
F	7.84±0.82 ^a	7.66±0.85 ^a	7.36±1.04 ^{ab}	7.48±1.16 ^a	7.48±1.28 ^a	7.60±1.23 ^{ab}	7.70±0.97 ^a
G	8.66±0.96 ^b	8.72±0.57 ^b	8.54±0.67 ^a	8.58±0.75 ^c	8.76±0.65 ^c	8.80±0.49 ^c	8.78±0.5 ^c

- A= Hausa Red bell pepper jam (sorbitol and sugar mixture)
- B= Yoruba red bell pepper jam (Sugar and sorbitol mixture)
- C= Yoruba red bell pepper jam (honey mixture)
- D= Hausa red bell pepper (honey mixture)
- E= Yoruba red bell pepper jam (sugar mixture)
- F= Hausa red bell pepper jam (sugar mixture)
- G= Strawberry jam (commercial)

PHYSICOCHEMICAL AND SENSORY PROFILE OF MARMALADE DEVELOPED FROM JACKFRUIT (*ARTOCARPUS HETEROPHYLLUS* LAM) BLENDS.

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ABSTRACT

The physicochemical and sensory analysis of marmalades produced from blends of Jackfruits, orange and velvet tamarind were studied. The samples were analyzed for pH, total titratable acidity (TTA), total dissolved solids (TDS), °Brix value, vitamin C and calcium contents using standard methods. The sensory profile of the marmalade samples were carried out using 20 member panelists on taste, texture, appearance, spreadability and overall acceptability using 9-point Hedonic scale. The results showed that there were significant ($p < 0.05$) differences in the physicochemical and sensory profile of the marmalade samples. The total titratable acidity results of the samples showed that sample D (80% JFJ: 20% OJ) had the highest total titratable acidity while sample A (100% JFJ) had the least TTA (0.47%) value. However, the 100% JFJ Marmalade (sample A) recorded the highest °Brix (5.21 °Brix) level while sample E (80% JFJ: 20% VJ) had the highest (68.55) total dissolved solids (TDS) contents and were significantly ($p < 0.05$) different from other samples. The pH values of the marmalade samples ranged from 2.75 to 3.65 which were low. However, the 80% JFJ: 20% OJ (sample D) had the highest vitamin C content (17.96 mg/100g) while 80% JFJ: 20% VJ had the highest calcium content (33.21 mg/100g). The Sensory profile results showed that the 80% JFJ: 20% OJ marmalade was most preferred by the panelists with an overall acceptability score of 6.70.

Keywords: Marmalade, Jackfruit juice, Physicochemical, Sensory, Blends.

INTRODUCTION

Marmalade is a semi-solid gel like or jelly like product prepared from fruits with one or more sweetening agents which may contain suitable food acids and food pectin. The ingredients are concentrated by cooking together fruit mixtures to a total soluble solid (TSS) of not less than 65% of the finished marmalade (Anne, 2010). Marmalades are mostly made from citrus fruits like lemon, orange, lime, grapefruits, etc. Marmalade production is one of the traditional preservation techniques that can be applied to fruits. Jackfruit (*Artocarpus heterophyllus lam*) also known as 'ukwa-bekee' in Igboland in Southeastern part of Nigeria is an underutilized fruit in the family of *Moraceae*. It is also known as sycamore fruit in Nigeria. It is an excellent source of potassium, iron, sodium, zinc, carbohydrate, dietary fibre and protein in minute quantity.

In Nigeria, due to high level of ignorance on the nutritional level and health benefits of Jackfruit, it is not fully exploited, despite the fact that it has a very good sugar content and antioxidant activity (Ubi *et al.*, 2016). It is locally grown in Nigeria but it is only consumed in its fresh form due to little or lack of knowledge on how to preserve or use the fruit during off season thereby, high post-harvest losses is incurred. Underutilized fruits are processed and added value by processing into various products like confectionary, jam, pickles, jelly, dried fruits, wine, fruit drinks, marmalade, etc. The production of marmalades from Jackfruit, orange and velvet tamarind blends will add variety to marmalade available in the market and improve its nutritional values. Therefore the objective of this study was to evaluate the physicochemical and sensory profile of the marmalades produced from Jackfruit, orange and velvet tamarind blends.

MATERIALS AND METHOD

Jackfruits (*Artocarpushetrophyllus Lam*) used in this study were bought from Ochanja Market in Anambra State,

Nigeria while other fruits (orange and velvet tamarind) were bought from Relief Market, in Owerri, Imo State.

Sample preparation

Ripe and wholesome Jackfruits, orange and velvet tamarind were used for the production of marmalade. The fruits were sorted and washed to remove dirt and sands. Wholesome fruits were selected based on firmness, maturity, color and freedom from insect damage or mechanical injury. In the processing of the fruits into juice, the Jackfruit were washed with potable water, cut open into six parts with a sharp stainless-steel knife to extract the pulp which holds the seeds and seed coat. The seeds were removed from the pulp before the pulp was shredded into smaller sizes to enable easy blending. The oranges were peeled and its juice extracted, while (300g) of dehulled velvet tamarinds were soaked in 400mL of warm water (65°C) for 30 minutes to soften the fruits. The bottles for packaging, blender container, knives, measuring cylinder, and other equipment were washed and sterilized.

Production of juice

Two kilograms (2kg) of Jackfruit pulp was shredded into pieces and blended in an electric warring blender using four thousand milliliters (4000mL) of water to produce the Jackfruit juice. The juice of the Jackfruit pulp was not strained while the juices of both orange and velvet tamarind were strained. The juices were pasteurized at 80°C for 10 min in order to destroy spoilage microorganisms and inactivate enzymes.

Production of Marmalade

Marmalade was produced by using the method of (Inam *et al.*, 2012) with slight modifications. The juice of Jackfruit, orange and velvet tamarind were weighed at different proportions to produce a blend for marmalade production. For 100% Jackfruit Marmalade, 500g of Jackfruit juice was weighed, mixed thoroughly with 100g of sugar and 4g of pectin. The mixture was boiled for 15min, added 4g of citric acid and allowed to boil for another 5min. The second and third Marmalade products were produced with 450g Jackfruit

juice(JFJ)+50g orange juice(OJ) and 450g Jackfruit juice(JFJ) + 50g velvet tamarind juice(VJ), for 90% : 10% proportion while the fourth and fifth products were developed from 400g Jackfruit juice(JFJ) +100g orange juice(OJ) and 400g Jackfruit juice(JFJ) +100g velvet tamarind juice(VJ) for 80% : 20% proportion. The prepared marmalades were poured into sterilized cans immediately and allowed to cool at room temperature.

Physicochemical analysis

Physicochemical analyses were carried out on the marmalades on total titratable acidity(TTA), total dissolved solids(TDS), °Brix, pH, vitamin C and calcium contents. The total titratable acidity, calcium, pH and vitamin C of the samples were determined by AOAC(2002), AOAC(1990), AOAC(2004) and Riemschneider *et al.*(1976) respectively. The °Brix level of the marmalade samples were determined by (AOAC, 2004) using a hand held refractometer while the total dissolved solids were determined by (AOAC, 2006) using a TDS meter(ATP instrumentation-TDS-5031 meter high range, UK).

Sensory evaluation

Sensory evaluation were carried out using twenty (20) member panelists on taste, texture, appearance, spreadability and overall acceptability using 9 point hedonic scale (Iwe, 2010). All the data generated were analyzed using analysis of variance (Anova) and means separated by Fischers least significance test.

RESULTS AND DISCUSSION

Results in Tables 1 and 2 showed the physicochemical properties and sensory profile of the prepared marmalades. The Total Titratable Acidity (TTA) of the samples ranged from 0.47% to 1.18%. The highest TTA (1.18%) was recorded in sample D (80% JFJ: 20% OJ). This could be attributed to the presence of acids in the orange juice which is released during blending. It was significantly ($P<0.05$) different from the other samples, and within the range value of (Inam *et al.*, 2012) in mixed fruit marmalade but lower than the values of (Emelike and Akusu, 2019) marmalade from tropical fruits. All samples were significantly ($P<0.05$) different from each other. Sample A (100% JFJ) had the lowest TTA (0.47%) value. The Total Dissolved Solids of the samples ranged from 39.10 to 68.55. Sample E (80% JFJ: 20% VJ) had the highest TDS (68.55) and was significantly ($P<0.05$) different from other samples. The high content of Total Dissolved Solids in sample E could be due to the chemical reactions between the organic constituents of the marmalade. Sample B (90% JFJ: 10% OJ) had the lowest TDS(39.10) and was not significantly ($P>0.05$) different from sample D (39.75). Samples A (55.41) and C (55.65) were not significantly ($P>0.05$) different.

The Brix content is an important parameter in the production of marmalade which measures the sugar content. The sugar content of the samples ranged from 4.51°Brix to 5.21°Brix which is low when compared to marmalades as reported by (Emelike and Akusu, 2019; Inam *et al.*, 2012). This could be due to the low amount of sugar used

during production. The highest Brix (5.21°Brix) was recorded in sample A (100% JFJ) as it has high amount of natural sugar that gives it a sweet taste and was significantly ($P < 0.05$) different from other samples which contained combination of fruits. All samples were significantly ($P < 0.05$) different from each other in terms of °Brix content. Sample E (80% JFJ: 20% VJ) blend had the lowest Brix (4.51 °Brix) level. The pH values of the marmalade samples ranged from 2.75 to 3.65. Sample D (80% JFJ: 20% OJ) had the highest pH value (3.65) and was not significantly ($P > 0.05$) different from sample E (3.59) which was prepared from 80% JFJ: 20% VJ. This suggests that the marmalade samples are acidic range. The natural pH level of the selected fruits may be responsible for the acidic pH level which is desirable for the inhibition of bacterial growth and this implies that the samples could keep longer. The vitamin C content of the samples ranged from 8.41 to 17.96mg/100g. Sample D (80% JFJ: 20% OJ) had the highest vitamin C (17.96mg/100g) content and was significantly ($P < 0.05$) different from other samples. The vitamin C values obtained in this study conform to the content of Jackfruit pulp which increased when supplemented with other fruits. Okegbile *et al.* (1991) stated that there was a high content of vitamin C and other micronutrients in wild fruits when compared to other fruits. The result of the level of vitamin C content in this study indicates that it could be relevant in preventing scurvy. Sample A (100% JFJ) had the lowest vitamin C (8.41mg/100g) content and was significantly ($P < 0.05$) different from other marmalade samples. However, the calcium content of the samples ranged from 10.06 to 33.21mg/100g. Jackfruit is rich in minerals such as sodium, phosphorus, sulphur, zinc, iron, potassium, copper, magnesium and calcium (Abedin *et al.*, 2012). Calcium and magnesium absorbed help in strengthening the bones and prevents bone-related disorders such as osteoporosis (Singh *et al.*, 1991). Sample E (80% JFJ: 20% VJ) had the highest calcium (33.21mg/100g) content and was significantly ($P < 0.05$) different from the other samples. Sample A (100% JFJ) had the lowest calcium (10.06mg/100g) and was significantly ($P < 0.05$) different from other samples.

The sensory parameters of the samples were significantly ($P < 0.05$) different from each other.

The taste scores of the marmalade samples ranged from 5.05 to 6.05. This could be attributed to the high sugar content in the Jackfruit and orange and high amount of tartaric acid found in the velvet tamarind. Sample E (80% JFJ: 20% VJ) had the highest taste score (6.05) which indicates slightly liked and most preferred and was not significantly ($P < 0.05$) different from sample A (6.00) which was prepared from (100% JFJ). Sample B (90% JFJ: 10% OJ) had the lowest taste score (5.05) and was significantly ($P < 0.05$) different from other samples. The appearance of the samples ranged from 6.55 to 7.80. Sample B (90% JFJ: 10% OJ) had the highest appearance score (7.80) which shows that sample B was most preferred by the panelists in terms of appearance and was significantly ($P < 0.05$) different from other samples except sample D (7.65) which was formulated from (80% JFJ: 20% OJ) blend. Sample E (80% JFJ: 20% VJ) had the lowest appearance score (6.55) and was not significantly ($P > 0.05$)

different from sample C (6.70) which was developed from (90% JFJ: 10% VJ) blend and sample A (6.85). The spreadability scores of the samples ranged from 5.65 to 6.70. Sample B (90% JFJ: 10% OJ) had the highest spreadability score (6.70), which shows that the sample was most accepted by the panelists in terms of spreadability. Sample B (6.70) was not significantly ($P < 0.05$) different from sample C. Sample A had the lowest spreadability score (5.65) and was not significantly ($P < 0.05$) different from sample E (5.70). However, the overall acceptability of the samples revealed that sample D (80% JFJ: 20% OJ) had the highest overall acceptability score (6.70) which shows that the sample was liked moderately by the panelists, most preferred and significantly ($P < 0.05$) different from other samples. Sample E (80% JFJ: 20% VJ) had the lowest overall acceptability score (5.80) and was not significantly ($P < 0.05$) different from sample C (5.90) which was developed from 90% JFJ: 10% VJ blend.

CONCLUSION

This study has revealed that the application of Jackfruit, orange and velvet tamarind blends in the production of marmalade is feasible. The physicochemical properties showed that sample D (80% JFJ: 20% OJ) had the highest vitamin C content (17.96mg/100g) while sample E (80% JFJ: 20% VJ) had the highest calcium content (33.21mg/100g). The pH and total titratable acidity (TTA) of all the marmalade samples were low which implies that they could keep longer since low acidic medium inhibits microbial growth. The sensory analysis showed that sample D (80% JFJ: 20% OJ) marmalade had the highest overall acceptability score of 6.70 and most preferred by the panelists than other marmalade samples.

Table 1: Physicochemical properties of marmalade samples

Sample	TTA	TDS	Brix (°Brix)	pH	Vitamin C (mg/100g)	Calcium (mg/100g)
A	0.47 ^c ±0.00	55.41 ^b ±0.06	5.21 ^a ±0.00	2.75 ^b ±0.7	8.71 ^c ±0.00	10.06 ^c ±0.01
B	0.97 ^b ±0.00	39.10 ^c ±0.07	4.81 ^b ±0.07	2.94 ^{ab} ±0.01	15.72 ^b ±0.00	29.06 ^d ±0.00
C	0.77 ^d ±0.00	55.65 ^b ±0.07	4.71 ^c ±0.01	3.37 ^{ab} ±0.00	9.55 ^d ±0.07	31.54 ^b ±0.00
D	1.18 ^a ±0.00	39.75 ^c ±0.07	4.61 ^d ±0.01	3.65 ^a ±0.00	17.96 ^a ±0.00	30.42 ^c ±0.00
E	0.92 ^c ±0.00	68.55 ^a ±0.07	4.51 ^c ±0.00	3.59 ^a ±0.00	10.23 ^c ±0.00	33.21 ^a ±0.00
LSD	0.014	6.36	0.021	0.64	0.06	0.00

Means with different superscript within the same column are significantly ($p \leq 0.05$) different.

Key:

Sample A: Marmalade made from 100% Jackfruit juice

Sample B: Marmalade made from 90% Jackfruit juice: 10% Orange Juice

Sample C: Marmalade made from 90% Jackfruit Juice: 10% Velvet Juice

Sample D: Marmalade made from 80% Jackfruit Juice: 20% Orange Juice

Sample E: Marmalade made from 80% Jackfruit Juice: 20% Velvet Juice

TTA: Total titratable acidity

TDS: Total dissolved solids

Table 2: Sensory scores of marmalade samples

Sample	Taste	Texture	Appearance	Spreadability	Overall acceptance
A	6.0 ^a ±1.38	5.70 ^a ±1.30	6.85 ^b ±1.15	5.65 ^b ±1.25	6.00 ^{ac} ±1.00
B	5.05 ^b ±1.25	6.25 ^a ±1.29	7.80 ^a ±1.10	6.70 ^a ±1.26	6.50 ^{ab} ±1.00
C	5.70 ^{ab} ±1.30	4.75 ^b ±0.90	6.70 ^b ±1.12	6.60 ^a ±1.56	5.90 ^c ±0.96
D	5.70 ^{ab} ±1.38	5.85 ^a ±1.26	7.65 ^a ±0.93	6.20 ^{ab} ±1.50	6.70 ^a ±0.80
E	6.05 ^a ±1.54	4.85 ^b ±1.42	6.55 ^b ±1.09	5.70 ^b ±1.34	5.80 ^c ±0.69
LSD	0.72	0.66	0.66	0.74	0.46

Means with different superscript within the same column are significantly (p<0.05) different.

Key:

Sample A: Marmalade made from 100% Jackfruit juice

Sample B: Marmalade made from 90% Jackfruit juice: 10% Orange Juice

Sample C: Marmalade made from 90% Jackfruit Juice: 10% Velvet Juice

Sample D: Marmalade made from 80% Jackfruit Juice: 20% Orange Juice

Sample E: Marmalade made from 80% Jackfruit Juice: 20% Velvet Juice

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EFFECTS OF DIFFERENT PACKAGING MATERIALS ON THE PROXIMATE AND MINERAL COMPOSITIONS OF DEHYDRATED RIPE CASHEW APPLE SLICES

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ABSTRACT

Cashew (*Anacardium occidentale*) fruits are highly perishable and seasonal and there is little information on their conversion into products of value. Dehydration of cashew apple at mild temperature will extend its shelf life and ensures its availability throughout the year. Ripe cashew apples were cleaned, sliced and dehydrated at 50 °C for 24 hours, cooled and kept in glass, polyethylene bags and plastic containers for three months. During the storage periods, cashew samples were assayed for proximate and mineral contents using standard methods. At the end of storage, proximate compositions of the dehydrated cashew samples were significantly different among packaging materials. Product inside the glass containers had better proximate composition than those in the plastics while dehydrated samples in the polyethylene bags had least value. Similarly, the moisture content of the dehydrated cashew samples packaged in the high density polyethylene bags increased significantly from 13.97 to 15.09%. Minerals contents of the dehydrated cashew also differed significantly from the initial mineral contents recorded on day zero. On day zero, the calcium content of the dehydrated cashew slices was 7.14 ppm and declined to 6.10, 5.19 and 5.06 ppm at the end of three-month storage respectively when glass, plastic and polyethylene bags were used as packaging materials. Packaging of dehydrated cashew apple slices in glass container minimized compositional changes in the product at the end of three-month storage.

Keywords: Dehydration, cashew apple, mineral contents, glass container, polyethylene bags

INTRODUCTION

High post-harvest losses of fresh fruits form one of the big issues Nigeria is facing during the period of plenty. Generally, fresh fruits contain large quantities of water, increase in susceptibility of ripe fruits to microbial attack due to increase in softness and loss of intercellular cohesion associated with ripening. These factors make fruits to be highly perishable as they influence infection process thereby making the host tissue more vulnerable to the digestive action of enzymes produced by the invading microbes (Aworh, 2010). Some of the fruits that are susceptible to post-harvest infections and of course losses include African cashew apple, mango, African star apple, orange, banana, tomato, plantain, hog plum, black plum among others. Similarly, most of these fruits contain appreciable amount of sugar (Aworh, 2010), especially the ripe ones, which is a suitable substrate required by microorganisms such as yeasts for their growth. Other important factors that are responsible for bio-deterioration of fresh fruits after harvest include presence of vitamins (such as vitamin C and A), minerals (such as iodine, iron, calcium, phosphorous etc.) and fibre.

Cashew fruits (*Anacardium occidentale*) are commonly known as "apples," and are gotten from the evergreen cashew tree. It is indigenous to Brazil and is an evergreen nut-bearing tropical plant that grows in latitude 15° north and south of the equator. It is a multipurpose tree crop with great economic importance to the developing countries including Benin Republic, Brazil, Cote d'Ivoire, Guinea Bissau, Ghana, India, Mozambique, Nigeria, Philippines, Sri Lanka, Tanzania and Vietnam (Adeigbe *et al.*, 2015). Cashew was introduced into Nigeria between 15th and 16th centuries by the Portuguese explorers (Ventakaramah, 1976). The plant was purposively used to control erosion, but became a popular crop in 1953 when it was planted on a large scale mainly for nuts, afforestation and erosion prevention.

Structurally, cashew fruit contains apple that is connected to a seed (popularly known as cashew nut). The weight of apples is about ten times the weight of nuts while average weight of nuts varies between 3 and 15 g. Cashew nut has two shells: a hard exterior shell and a testa. The testa is a thin brown skin (a fine, brown seed coat), inside the hard shell. It is wrapped around a slightly curved fleshy kernel. The testa protects the kernel from penetration by atmospheric oxygen, so preventing it from becoming rancid (oxidative rancidity) as it contains antioxidants (Onilude *et al.*, 2010). The cashew nuts are the most popular part of the cashew tree as they are favourite of many because of their nutrient-rich profile. Despite the nuts' dietary praise, their apples (or pseudo fruits) remain mostly out of the spotlight (Ximena, 2021) and are discarded as wastes resulting in environmental pollution. Processing of fresh cashew apples, using appropriate technology, will promote its use in feed and food formulations. This presumably will also minimize environmental pollution and post-harvest losses in fresh cashew apples.

Since cashew apple is very high in water and seasonal, dehydrating it at a controlled temperature as well as proper packaging of the processed cashew apple slices will not only address seasonality issue but also preventing undesirable smell from rotten cashew apples. Cashew fruits are considered good sources of micronutrients such as vitamins (thiamine, niacin, riboflavin, β -carotene (vitamin A precursor), vitamin C, antioxidants (carotenoids and phenolics) and macronutrients including reducing sugars and amino acids (Agbangnan *et al.*, 2018). Considering these nutrient profiles, dehydrated cashew apple can be eaten as healthy snacks and has also added value to cashew apple. Therefore, the objectives of this study are to develop value-added product from cashew apple by dehydration and evaluate the effects of glass bottles, plastic and polythene bags on its quality after three month storage at room temperature.

Materials and Methods

Cashew fruits were harvested from the farm in Ikoyi-Ile, Oyo state, Nigeria. The fruits were carefully arranged in the crates and brought to Food Science and Technology Laboratory, Kwara State University, for analysis.

Sample preparation

Cashew fruits were sorted, followed by removal of their seeds, washing with potable water and drained. Washed cashew apples were then sliced uniformly (6mm thickness), weighed, arranged on the trays and then dried in the hot air oven at 50 °C for 24 hours. Just after dehydration, dehydrated slices were removed from the trays, cooled, and then packaged inside three different packaging materials (Glass, High density polyethylene bags and Plastic) and stored at room temperature for

three months. During the storage period, samples were taken every month for proximate and mineral contents assessments, and day zero sample was used as control.

Chemical analyses of dehydrated cashew slices
Proximate analysis of dehydrated cashew apple slices

The samples were analyzed for moisture, crude protein, fat, fibre and ash according to procedure described by AOAC (2005) while carbohydrate contents were determined by difference.

Mineral contents determination

For mineral content determination, dehydrated cashew samples (5g each) were ashed, and the metallic contents (calcium, sodium,potassium, copper, zinc, magnesium, and iron) were determined using Perkin Elmer Analyst 200 Atomic Absorption Spectrophotometer.

Statistical analysis

All tests were done in triplicates and data obtained were statistically analyzed using a one-way analysis of variance (ANOVA). Means were tested for significance difference by Duncan’s Multiple Range Test and Significance difference was accepted at $p < 0.05$.

Resultsanddiscussion

Proximate compositions of 3-month stored ripe cashew apple slices

The changes observed in proximate compositions ofday zerodehydrated and 3-month stored cashew apple slices are presented in Tables 1. Proximate compositions of the dehydrated cashew samples were significantly different among containers used as packaging materials. Product kept inside the glass container had better proximate composition than those in the plastic containers while dehydrated cashew samples in the polyethylene bags had least proximate values at the end of three month storage at room temperature. For instance, the moisture content of the dehydrated cashew samples packaged in the high density polyethylene bags increased significantly from 13.97 to 15.09%. This is because polyethylene bags are permeable to moisture, gases and vapour(Marsh and Bugusu, 2007), and this could trigger compositional changes that might result in short shelf life of the dehydrated product kept in it.Glass containers maintained the crispiness of the cashew samples kept in ittill the end of 3-month storage period.

Table 1: Results of proximate compositions of 3-month stored dehydrated cashew apples slices

samples		moisture %	ash %	crude fiber%	crude fat%	crude protein%
carbohydrate%						
dried	13.97±0.05d	2.82±0.04a	4.74±0.05bc	1.02±0.00b	4.54±0.08b	72.91±0.12b
glass	13.99±0.07c	2.64±0.08b	4.59±0.24cd	1.09±0.07b	4.54±0.35b	73.15±0.55a
plastic	14.68±0.36c	2.12±0.11c	4.81±0.16ab	1.11±0.09b	4.88±0.19a	72.40±0.79c
nylon	15.09±0.37b	2.07±0.07c	4.98±0.71a	1.15±0.14b	4.95±0.39a	71.76±0.97d
mean	20.94	2.21	4.7 5	1.18	4.33	72.56
p-level	***		***	***	***	***

Values are means ± standard deviation of triplicate determinations

Key

Nylon: High Density Polyethylene (HDPE)

Dried: Dehydrated cashew apple slices on day zero

Mineral contents of 3-month stored cashew appleslices

Food packaging materials play important roles in protecting foods from three major factors such as chemical, biological and physical factors thereby retarding food deterioration and extending shelf life (Marsh and Bugusu, 2007). Effects of different packaging materials on the mineral contents of dehydrated cashew apple slices are shown on Table 2. At the end of three month storage, minerals (Na, Cu, Zn, Ca, Mg, K, and Fe) in the cashew samples stored in the glass, polyethylene bags and plastic containers differed significantly ($p < 0.05$) from the initial mineral contents recorded on day zero. However, dehydrated cashew slices stored inside the glass container had highest mineral contents while those in the polyethylene bags had least mineral contents. For instance, on day zero, the calcium content of the dehydrated cashew slices was 7.14 ppm and declined to 6.10, 5.19 and 5.06 ppm at the end of third month of storage respectively when glass, plastic and polyethylene bags were used as packaging materials. This is in line with Marsh and Bugusu (2007) that reported that glass containers offer better protection to food than most packaging materials.

Table 2: Results of mineral contents of 3-month stored cashew appleslices

Sample	Na (ppm)	Cu (ppm)	Zn (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Fe (ppm)
Dried	14.23±0.00a	0.14±0.00ab	0.42±0.00a	7.14±0.00a	12.17±0.00a	31.64±0.00a	0.06±0.00a
Glass	11.92±1.17b	0.12±0.01ab	0.29±0.09a	6.10±0.43b	10.06±0.79b	29.27±0.77b	0.04±0.01b
Plastic	8.51±1.06c	0.53±0.47a	0.19±0.04c	5.19±0.20c	8.07±0.91c	25.52±1.35c	0.03±0.01c
Nylon	9.36±1.18c	0.11±0.01ab	0.30±0.02a	5.06±0.64c	8.86±1.28bc	27.62±1.30b	0.04±0.01bc
Mean	10.50	0.22	0.28	5.75	8.87	26.57	0.04
P-level	***	**	*	***	***	***	***

Conclusion

Value-added product in form of dehydrated cashew apple slices, that will be available when fresh cashew apple is off season, was produced. Similarly, at the end of this study, it was revealed that the three packaging materials have varying protection potentials, however, glass container retained the proximate compositions and mineral contents of dehydrated cashew apple slices better than those kept in plastics and high density polyethylene bags. Dehydration of cashew apple slices and use of glass bottle as its packaging material will reduce postharvest losses associated with it especially during the period of plenty.

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EVALUATION OF ANTIOXIDANT ACTIVITY AND STABILITY OF MICROENCAPSULATED GREEN TEA EXTRACTS USING SIMULATED *IN VITRO* DIGESTION

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Abstract

There is a growing awareness that there is direct link between health and diet which has led to increasing interest in development of new food products and food ingredients. A lot of emphasis has been devoted to the development of functional food products enriched with natural plant extracts. Catechins obtained from green tea leaves extracts has been reported to possess antimicrobial, antihypertension, antiobesity, anticholesteremic and inflammatory effects. In vitro studies showed that catechin from tea (*Camellia sinensis*) extract is a powerful antioxidant. However, studies suggest that catechin undergo modification leading to the formation of glucuronide conjugates which are more polar and are easily excreted before reaching their target cells compared to the parent compounds. It has also been reported that microencapsulation will improve stability of green tea flavan-3-ols substantially leading to improved bioavailability. The extract was incorporated into biopolymers by spray drying using a blend of maltodextrin, gum arabic and chitosan. In vitro study was carried out using simulated gastric and intestinal fluids for 120 minutes to evaluate the antioxidant activity. Catechin compounds released via dialysis bag during *in vitro* studies retain their antioxidant properties. This study showed that green tea catechin microparticles retained its bioactivity with minimum modification in simulated gastrointestinal fluids.

Key words: Green tea extract, Microparticles, In vitro study, Functional food.

INTRODUCTION

Tea (*Camellia sinensis*) is a beverage consumed all over the world second to water. Tea has become a subject of intense study for the past five decades because of the associated health benefits such as the anti-cancer, anti-inflammatory, antioxidant properties; which has been widely reported (Deka, 2011). Green tea (*Camellia sinensis*) extracts are rich in catechin. Furthermore, a lot of emphasis has been devoted to the development of functional food products enriched with natural plant extracts such as tea. However, stability of tea catechin polyphenols is very poor which is one of the primary problems associated with consumption of green tea (Shim et al., 2012). In vitro studies showed that catechin from green tea extract is a powerful antioxidant, five times more than vitamin C. However, studies suggest that catechin undergo modification leading to the formation of glucuronide conjugates which are more polar and are easily excreted before reaching their target cells compared to the parent compounds. It has also been reported that microencapsulation will improve stability of green tea flavan-3-ols substantially leading to improved bioavailability. It is important to determine the stability of green

tea bioactive (catechin). Factors influencing stability of catechin during consumption are light, temperature, pH and oxygen and the level of oxidation. Alkaline environment such as the one obtain in the intestinal tract during digestion is one of the reasons leading to its poor bioavailability (Sessa et al., 2011).

Food grade encapsulation system is considered important innovative strategy to improve the bioaccessibility and bioavailability of green tea extract for oral administration. When green tea leaves extracts is encapsulated using biopolymer materials, it improves stability and serve as a vehicle to deliver the phenolic compounds to their target cells. In order to retain the needed health benefits, green tea extracts was encapsulated by spray drying using blend of biopolymers (maltodextrin, gum arabic and chitosan) as wall materials for this study. It is important to know whether microparticles of the encapsulated bioactive components are effectively released during digestion. It has been postulated that only catechin compounds released from the microparticles become bioaccessible for absorption by the gastrointestinal tracts thereby exerting the beneficial health effect. In this study, in vitro modeling system of gastric phase and intestinal phase were simulated using dialysis tubes. Microparticles of encapsulated green tea catechins bioactive fractions as a reference polyphenolic compound was evaluated in this paper using simulated gastric and intestinal fluids (SGF & SIF) respectively. Information on stability of the encapsulated catechin microparticles during in vitro studies; was investigated spectrophotometrically by determining free radical scavenging activity retention represented by DPPH of simulated SGF and SIF.

Material and Methods

Fresh young green tea leaves were obtained from BOH tea plantation Cameron Highlands, Malaysia and was processed to obtain green tea powder to a particle size of about 500 μ g. Folin-ciocalteu phenol, 2,2-diphenyl-1-picrylhydrazyl (DPPH) reagent and other chemicals used in this study were purchased from Sigma Aldrich (St. Louis, MO, agents in Malaysia).

Green tea powder extraction : extracts of green tea was obtained using the method of (Maeda-Yamamoto, Ema, Tokuda, Monobe, Tachibana, Sameshima, 2011) with some modification. In brief, 2.0g of green tea leaves powder was extracted using 100 ML 70% food grade ethanol at 70°C for 30min with frequent stirring. The infusion was allowed to cool and was centrifuged and stored at 4°C.

Preparation microparticles of green tea extracts

A blend of commercial maltodextrin (MD), gum arabic (GA) and chitosan (CTS) using simplex centroid mixture of experimental design base on previous preliminary study by the same author was used. Carbohydrates wall materials were dispersed in distilled water and were dissolved individually at 40-60°C with constant stirring for 30 minutes to obtain a final volume of 200ml to a total solid of 18-21(°Brix). However, Chitosan was dissolved separately using 5% acetic acid since it is not readily soluble in water before adding under a magnetic stirrer before mixing properly. The mixture was homogenized using mini homogenizer (SP-8 Malaysia) at 8000-9500rpm for 5 minutes to achieve complete dispersion. Homogenate of the slurry was spray dried using Buch, 290 minispray drier (Buch-Switzerland at an outlet temperature of 150 $\pm$ 5°C. The inlet temperature was determined by the outlet temperature. The diameter of

the nozzle was 0.7mm at a feed flow rate of 23rpm (15ml/min). Microparticles were collected using glass chambers before storing in sealed aluminium pouches until further studies.

In vitro studies of encapsulated microparticles of green tea extracts

The method of (Rocha et al., 2011) with slide modification was adopted. Briefly, simulated gastric fluid (SGF) and intestinal fluid (SIF) pH 1.7-2.4 (0.1M HCL) and 7.4 (phosphate buffers) were formulated. Pre-weighed microparticles of green tea catechin 200mg were loaded in a previously soaked visking tubing dialysis tubes (2in. diameter 14.3/26mm pore size 25 angstroms (WMCO 1200-16000 Dalton, UK). The tubes were placed in a beaker containing 150ml simulated SGF and SIF respectively. The content was incubated at 37°C and was stirred using magnetic stirrer regularly at 50rpm during this period, aliquots samples from dialysate tubes solution were withdrawn regularly in order to determine total free radical scavenging activity (DPPH spectrophotometric method (Zokti et al., 2016)). Analysis was done to cover time intervals of 0, 20, 40, 60, 80, 100 & 120 minutes. The result was reported as free catechins that were able to cross the wall of dialysis.

Determination of 2,2 Diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay: The DPPH which represent the free radical scavenging activity was determined using the method of (Zokti et al., 2016). The DPPH was calculated as: %inhibition = $[(A_B - A_S)] \times 100$.

Where: A_B absorbance of blank

A_S absorbance of sample

% DPPH inhibition is expressed per mM equivalent trolox.

Ascorbic acid was used to prepare standard curve from 20 to 1000mM using Pearson's correlation coefficient

Statistical analysis

Design Expert Software version 16 was used for analysis of result. Data were statistically performed using one-way ANOVA (analysis of Variance).

Result and Discussion

Highly reactive free radicals are considered harmful to human health. It is therefore important to evaluate their stability in the constructed green tea encapsulated microparticles in simulated gastrointestinal tract. Retention of free catechins compounds from the *in vitro* study was evaluated based on antioxidant scavenging capacity (DPPH) in (SGF) and (SIF). Catechins are highly soluble in fluids that are alkaline such as the one obtained in the human gastrointestinal region. The Low bioavailability (< 2%) has been associated with degradation of catechin under intestinal pH (Peters, Green, Janle, & Ferruzzi, 2010;).

Fig.1&2 showed the release catechin antioxidant of encapsulated microparticles in simulated intestinal fluid (SIF) and simulated gastrointestinal fluid (SGF). The microparticles release higher rate of DPPH in SIF than those of simulated gastric fluid SGF. All microparticles release over 82 – 95% of their contents between 20 to 60 minutes; except for microparticles

containing maltodextrin: gum arabic : chitosan (25:74:1) and gum arabic 100% (MD; GA: CTS(0:100:0)which showed slight delay released within the maximum time 120 minutes. When taken into consideration the release of catechin phenolic compounds in SGF and SIF, we found out that microparticles provide high release in intestinal fluid conditions compared to gastric conditions. Therefore total phenolic compound is positively associated with phenolic substances in the green tea samples. This pattern of release can be attributed to microparticles - water interaction because of the amorphous physical condition of the powders which results in enhanced solubility. Sansone et al., (2011) have reported similar pattern in their study. In our study, the high solubility nature of maltodextrin and hydrophilic nature of gum arabic may be the reason for rapid release of catechin antioxidant observed in the simulated gastro intestinal fluid conditions. The delay in the release of the particles containing chitosan can be associated to its high molecular weight and low solubility in water when compared to maltodextrin and gum arabic. This behaviour has also been reported by Siripatrawan & Noipha, (2012). In another study designed to determine the release of bayberry polyphenols, Zheng et al. (2011) reported that less release was observed under the SGF while most of the release (82 -98%) took place during the first 40 under the SIF condition. The results of *in vitro* retention of catechins showed that the rate of retention of catechin in the microparticles was in the order of gum arabic > maltodextrin: gum arabic > maltodextrin > maltodextrin: gum Arabic: chitosan. The carrier blends of maltodextrin: gum arabic: chitosan (25:74:1) showed the lowest catechin retention, while 100% gum arabic carrier agent gave the highest retention capacity. We can conclude that catechin remain encapsulated in the carrier materials without undergoing conformational changes (Epimerization, Oxidation, metabolised or degradation) in the simulated gastrointestinal fluids for the period of incubation, and are likely to remain in their active forms to be absorbed after consumption. The result shows that the sustained release of green tea catechin from the microparticles can lead to reduction of chemical degradation in the gut condition. Thus, we could exploit the ability of the microparticles to stabilize the green tea catechin for food application to deliver catechin in drinks.

The result the *in vitro* test in this study indicates that catechin polyphenol microparticles was adequately protected and may be available /stable for absorption in the intestine.

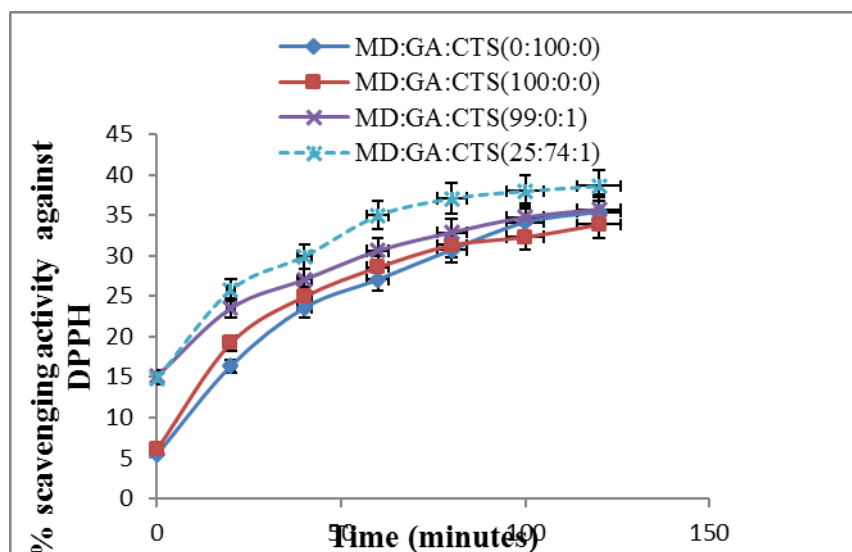


Figure 1. Effects of pH activated *in vitro* release antioxidant scavenging activity (DPPH) loaded microparticles in simulated gastric fluid (pH2.3) at 37°C for 120 minutes.

Fig.2

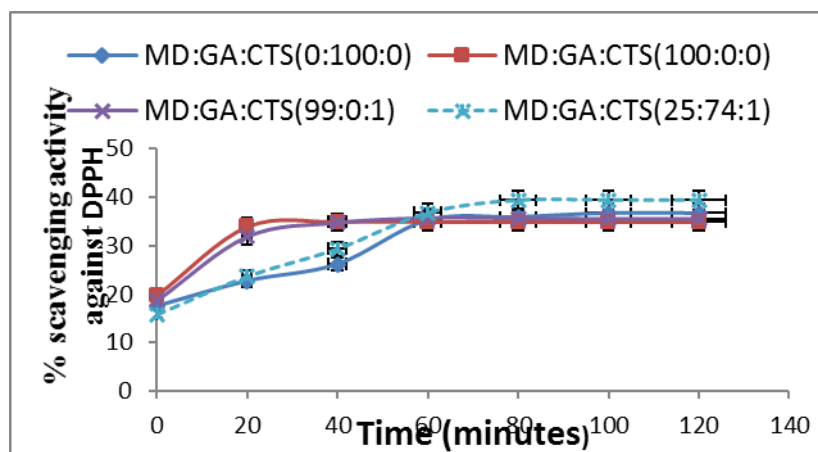


Figure2. Effects of pH activated *in vitro* release of antioxidant scavenging activity (DPPH) catechin loaded microparticles in simulated intestinal fluid (pH7.4) at 37°C for 120 minutes.

Conclusion

Antioxidant activity and stability of microencapsulated green tea extracts were influenced by the pH of the gastrointestinal environment and type of wall materials. Wall material containing blends of maltodextrin, gum arabic and chitosan was more stable in both SGF and SIF. Green

tea catechin antioxidants are more likely to reach target cells at higher concentration before release when encapsulated with the right polymer materials.

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TOXICITY EVALUATION OF PROCESSED TURMERIC USED AS AN OXIDATIVE HERBAL TEA USING ANIMAL STUDY MODEL

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ABSTRACT

Toxicity of turmeric consumption as tea was evaluated using animal study. The preparations of the turmeric tea sample at 5,000 mg/kg (I-low dose), and 10,000 mg/kg body weight (II-high dose), were administered by intubation according to body weight and observed (3h, 24h, 72h and 7 days) to determine acute toxicity and the abortifacient effects on pregnant rats on stages of pregnancy at 1st, 2nd and 3rd trimesters. Results of the acute toxicity study done reveal no clinical signs of toxicity in Wistar rats treated with the innovative turmeric tea on the experimental Wistar rats. The result of litter number and weight ranged from 6-7 and fetal weight 4.53 to 5.17 g respectively. The experimental turmeric tea infused in water is not toxic for consumption even at pregnancy when consumed moderately (5000-10000 mg/kg bw).

Key words: Turmeric, Toxicity, Wistar rats, Oxidative, Tea.

INTRODUCTION

Turmeric (*Curcuma longa* Linn.) is of the family Zingiberaceae grown for its medicinal, culinary, and other uses Aggarwal *et al.*, (2017). Turmeric has been consumed in various forms such as powder in liquid, as spice in cooking foods, coloring agent in food and beverages etc. Turmeric rhizomes are yellow in colour due to a phenolic pigment known as curcumin. Curcumin is the active principle responsible for its medicinal efficacies. Proximate composition of turmeric contained 8.92% moisture, 2.85% ash, 4.60% crude fibre, 6.85% fat, 9.40% crude protein and 67.38% carbohydrate (Mane *et al.*, 2018; Ahaotu and Lawal 2019). Turmeric has an oxidative potential, by virtue of its active ingredient curcumin, has been established to have healing potential effects on several diseases such as inflammatory, metabolic, endocrine, cardiovascular, gastrointestinal, neurological, respiratory, viral, skin diseases, and cancer, as contained in the review work by Tiziana, *et al.*, 2020.

Turmeric rhizomes dried powder dissolved in water is been taken in form of imitation tea. However, due to hazy nature of the tea solution, its consumption is not delightful compared to traditional tea products like Lipton tea, also, it has to be taken in very high dose to achieve its desired effects because curcumin has low oral absorption and the use of activating agent may translate to toxicity (Ganiger *et al.*, 2007). Though, researches have been done on turmeric toxicity and have been found to be safe (Madan *et al.*, 2016) but there is dearth of information on its toxicity when consumed as tea. Hence, the objective of this current study is to evaluate toxicity of consumption of turmeric as tea.

MATERIALS AND METHODS:

Oxidative herbal tea samples were formulated hygienically and fit for human consumption, from fresh turmeric rhizomes procured from National Root Crops Research Institute (NRCRI) out station, Maru, Kaduna State, Nigeria. One percent (1%) infusion of the turmeric oxidative herbal tea in hot water at 100°C was made as test sample in the study. Sixty-nine (67) Wistar strain Albino rats of different sexes, known age and body weight (both male and female) obtained from University of Nigeria Nsukka Enugu State Nigeria, was used in the study. The animals were acclimatized for three weeks, before commencement of experiments, given water and feed (Vital Feed® grower's mash) *ad libitum* daily at Michael Okpara University of Agriculture Umudike (MOUUAU) Abia State, Nigeria. Animal right ethical permission /certificate was processed and obtained. All the experimental procedures were carried out in strict compliance to the Institutional Ethical Instructions for animal study, as well as adequate consultations to the Experimental Ethic Committee (EEC) guidelines to laboratory animal care and use. Wistar rats of the same species/strain were maintained in the course of the study.

Animal Study Procedure:

Ethical Animal Right Permission was obtained from Experimental Ethic Committee, MOUUAU. The turmeric was prepared in form of tea at different experimental temperatures (30°C T3 & 100°C T1) and times (2, 4 & 6 Min.), administered to experimental rats by intubation. The animal study was done in two (2) phases (phase 1 acute toxicity test; and phase 2 the abortifacient study).

Phase 1: Thirty-nine (39) Wister rats were used for the determination of median lethal dose (acute toxicity testing) of the test sample. The up and down modified method described by [4] was adopted for this study. Higher dosage (10,000mg/kg bw.) than literature [2] reported assay (5,000mg/kg bw.). The method is summarized in Table 1.

Table 1: Acute Toxicity Test Dosage and Test Samples Administration

Group/ test sample	Concentration mg/ml	LowDoseMeanBody weight (g)	HighDoseMeanBody weight (g)	Low Dose 5000mg/kg bw Mean Qty(ml)	High Dose 1000mg/kg bw Mean Qty(ml)
TT32(n=6)	121.0	191.66	100.61	7.91	8.31
TT34(n=6)	135.7	208.0	114.0	7.68	8.39
TT36(n=6)	161.0	218.6	137.0	6.78	8.50
TT12(n=6)	236.1	208.1	134.6	4.40	5.70
TT14(n=6)	312.5	210.6	107.3	3.37	3.64
TT16(n=6)	344.0	204.0	135.6	2.96	3.93
Distilled water(n=3)		ND	201.5	5.0	5.0
Total no. of rat	39				

The median lethal dose (LD₅₀) of the crude extract was then calculated using the formulae:

$$LD_{50} = \sqrt{(\text{least dose with mortality} \times \text{Highest dose without mortality})}$$

Phase 2: Effect of Test sample on pregnant rats

Thirty (30) female Wister rats were used for the abortifacient study. The rats were allowed free access to feed and water *ad libitum* and observed for both acute and delayed signs of toxicity or possible death over a 72-hour period and 7 days respectively. This phase was divided into effect on pregnancy at different developmental stages. The sexually matured female rats were mated with sexually matured male rats in the ratio 1:3, and was separated base on the stage of pregnancy into 1st, 2nd and 3rd trimesters. The result of the acute toxicity testing was then used to determine the dosage in the main studies.

Group A: comprised of 9 pregnant rats at 1st trimester, divided into 3 groups with 3 rats each, which receive TT12, TT14, TT16 prepared forms of the test sample respectively, from day 1 – day 7 of pregnancy.

Group B: comprised of 9 pregnant rats at 2nd trimester, divided into 3 groups with 3 rats each, which received TT12, TT14, TT16 prepared forms of the test sample respectively, from day 8 – day 14 of pregnancy.

Group C: comprised of 9 pregnant rats at 3rd trimester, divided into 3 groups with 3 rats each, which received TT12, TT14, TT16 prepared forms of the test sample respectively,

from day 15 – day 21 of pregnancy.

Group D: comprised of 3 pregnant rats which received distilled water from day 1 – day 21 of pregnancy, and served as the control group [5].

Where TT32 = Turmeric infusion at 60°C for 2minutes; TT34 = Turmeric infusion at 60°C for 4minutes; TT36 = Turmeric infusion at 60°C for 6 minutes. TT12 = Turmeric infusion at 100°C for 2minutes; TT14 = Turmeric infusion at 100°C for 4minutes; TT16 = Turmeric infusion at 100°C for 6 minutes.

RESULTS AND DISCUSSIONS:

Acute Toxicity Test:

Results of the acute toxicity study done revealed no clinical signs of toxicity in Wistar rats treated with the turmeric tea. Equally there was no mortality both at the low (5000mg/kg bw) and high (10,000mg/kg bw) turmeric tea administered for 3hrs, 24hrs, 72hrs and 7days. This implies that consumption of the turmeric tea prepared at different experimental temperatures and times were safe at low and high concentrations.

Effect of the novel Turmeric Tea sample on pregnant rats:

Investigations of fertility test revealed no signs or symptoms of abortive tendency in any of the pregnant rats administered the innovative turmeric tea sample (TT16) at 3 pregnancy stages. No mortality mother or fetal was observed in any of the 3 trimesters. Fetal weight ranged from 4.53 to 5.17 and litter size 6 to 7. There was no significant difference compared with control pregnant Wistar rats in the litter sizes and fetal weights (g) as shown in Figure 1. This aspect of the study was undertaken to provide information that may be useful for the consumption of the turmeric tea during pregnancy. The result is within normal average range of litter size in Wistar rat (4-8) and fetal weight 3-7g. The information of litter size has great influence on the growth performance of animal (Chahoud and Paumgartten, 2009). Though, caution on consumption of curcumin extracted with bioavailability agents (activated) has been reported [2] but in this study water was used for the infusion. Perhaps, this may be the reason for the observed nontoxic effect at pregnancy (Shankar et al., 1980).

Where TT12 = Turmeric infusion at 100°C for 2minutes; TT14 = Turmeric infusion at 100°C for 4minutes; TT16 = Turmeric infusion at 100°C for 6 minutes. TT32 = Turmeric infusion at 60°C for 2minutes; TT34 = Turmeric infusion at 60°C for 4minutes; TT36 = Turmeric infusion at 60°C for 6 minutes.

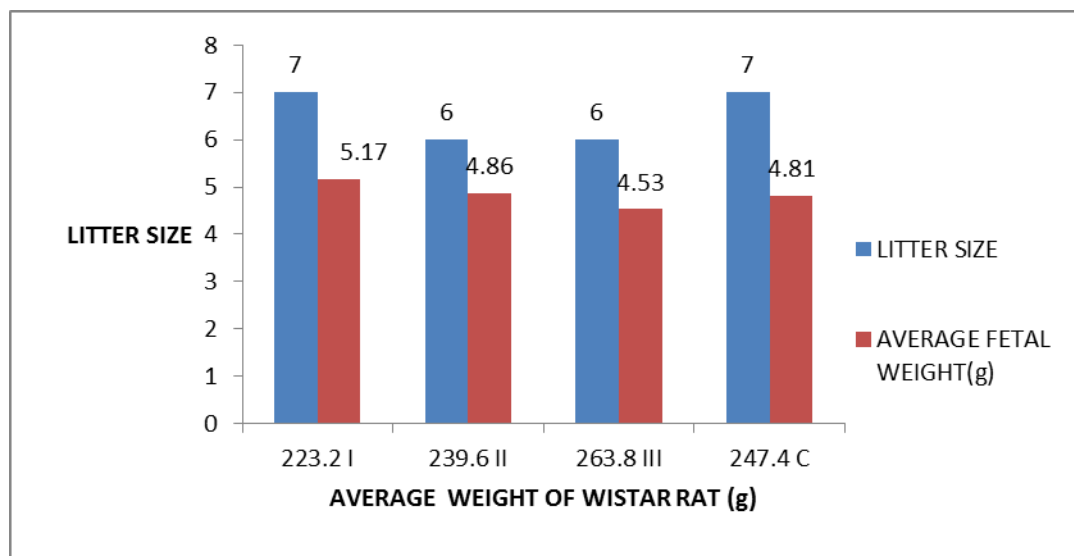


Figure 1: Average Litter size and fetal weight (g) at birth of pregnant wistar rats in first I, second II and third III trimesters, wher C is control

Conclusion

The experimental turmeric tea infused in water is not toxic for consumption even at pregnancy when consume moderately (5000-10000kg/g bw).

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IMPACT OF DEBITTERING AND SOLID-STATE FERMENTATION ON THE ANTINUTRITIONAL FACTORS AND ANTIOXIDANT ACTIVITIES OF *MORINGA OLEIFERA* SEED FLOUR

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Abstract

Moringa seeds are rich in proteins, micronutrients and bioactive constituents but its consumption is limited due to its high concentration of bitter alkaloids and other antinutritional factors (ANFs) that impede nutrient digestibility. In recent times, there is increasing interest in finding low-cost and effective processing technology for reducing ANFs in *moringa* seeds for improved nutrition and promotion of health. The aim of this study was to determine the impact of debittering (aqueous heat treatment) alone or in combination with fermentation on the antinutritional compounds and antioxidant activities of *moringa* seed flour. Results obtained revealed that debittering alone, and combined debittering and fermentation treatments significantly ($p \leq 0.05$) decreased phytic acid (61.65% and 92.85%, respectively), tannin (51.32% and 71.24%, respectively), trypsin inhibitors (57.95% and 81.54%, respectively), saponin (57.22% and 86.57%, respectively), nitrates (92.45% and 93.73%, respectively), urease activity (88.33% and 95.00%, respectively) and total alkaloids (67.49% and 92.93%, respectively), increased phenolics, antioxidant activities (ABTS, DPPH, FRAP and ascorbic acid) compared to the raw flour. The use of combined debittering and fermentation with *Saccharomyces cerevisiae* is thus recommended for debittering of *moringa* seeds.

Keywords: *Moringa Oleifera* seed, Debittering, Solid-state fermentation, Antinutrients, Antioxidant potential

1.0 Introduction

Moringa oleifera is an important traditional vegetable tree that grows in the tropics producing leaves and seeds of immense value in human nutrition. *Moringa oleifera* seeds are underutilized crops grown widely in the tropics. *Moringa seed* flour contain about 36.18% protein, rich in essential amino acids and micronutrients than most pulses (pigeon pea, cowpea, bambara nut, lentils and chickpea) but comparable to soybean flour (35 to 40%) (Ogunsina *et al.*, 2015). *Moringa* seed flour is usually blended with wheat flour to obtain a well-balanced protein diet. However, like other plant protein sources, *moringa* seeds contain antinutritional factors such as phytic acid, tannin, oxalate, saponin, trypsin inhibitor, alkaloids, among others (Sardabi *et al.*, 2022). Antinutritional factors limit the utilization of plant foods for human nutrition by impeding nutrient digestibility. The bitter taste of *moringa* seed flour

limits its food and industrial application. However, a debittering process has been applied to remove antinutritional factors and bitter compounds in legume seeds such as lupin making its flour safe for consumption (Villacrés *et al.*, 2020). Similarly, a few traditional debittering methods such as germination, natural fermentation and boiling have been used for debittering *moringa oleifera* seeds (Sardabi *et al.*, 2022). It has been established that heat treatment decreases antinutritional factors and increases nutrient digestibility in cereals and legumes. Particularly, aqueous heat treatment (AHT) is one of the debittering used in reducing bitter alkaloid content and antinutritional factors to safe level in *Lupinus campestris* seeds (Jiménez-Martínez *et al.*, 2001); the effect of debittering treatment using AHT method on the antinutritional factors in *moringa* seeds has not been studied. On the other hand, solid-state fermentation (SSF) with yeast (*Saccharomyces cerevisiae*) has been applied to reduce antinutritional factors and improve the nutritional quality of cereals and legumes (Chinma *et al.*, 2020). According to Villacrés *et al.* (2020), SSF with *Rhizopus oligosporus* strain increases the polyphenol content and improves antioxidant activity, because microbial action enables the breakdown of cell walls and allows the release or synthesis of antioxidant compounds that act as metal chelators or hydrogen donors to free radicals. Nevertheless, the impact of SSF with *Saccharomyces cerevisiae* on the antinutritional factors and antioxidant activities of *moringa* seed flour has not been determined. It can be hypothesized that debittering alone or combined debittering and SSF may modify antinutritional factors, total phenolics and antioxidant activities of *moringa* seed for improved nutrition. The objective of this study was to evaluate the impact of debittering or in combination with solid-state fermentation on the antinutritional factors and antioxidant activities of *moringa* seed flour.

2.0 Materials and methods

2.1 Materials

Moringa seeds and *Saccharomyces cerevisiae* (baker's yeast, Angel Yeast Company, Yichang Hubei, China) were procured from an Agro seed company and bakery shop, respectively, at Kubwa Main market Abuja, Nigeria. All chemicals used were of analytical grade.

2.2 Sample preparation

2.2.1 Preparation of raw *moringa* seed flour

Cleaned *moringa* seeds were washed with tap water, drained, and dried in air draft-oven (Gallenkamp, Cheshire, UK) at 50 °C for 24 h. The dried seeds were milled and sieved (screen diameter 100 µm) to produce raw *moringa* seed flour (RMOSF). The flour was defatted with n-hexane to obtain raw *moringa* seed flour which served as control.

2.2.2 Preparation of debittered flour

Debittered *moringa* seed flour was prepared following the aqueous heat treatment method described by Villacrés *et al.* (2020) with slight modification in terms of cooking time and washing period used. A 500 g of cleaned *moringa* seeds were soaked (1:3 w/v) at an initial temperature of 80 °C for 16 h. Thereafter, the samples were cooked in water (at grain to water ratio of 1:3, at 100 °C for 1 h) and washed with distilled water. The aqueous washing

of the grain was carried out in a stirring system (maintaining a grain to water ratio of 1:15). The first washing step was carried out with distilled water (at 35 °C for 5 h) while the second washing step involved washing at 18 °C for 5 h. Afterwards, the debittered *moringa* seeds were dried at 50 °C for 24 h, milled and defatted using n-hexane. The aqueous heat treatment of seeds was carried out in three batches. The defatted meal was blended and sieved (through 100 µm sieve) to obtain debittered *moringa* seed flour (DMOSF). The flour sample was stored in plastic containers with lids prior to subsequent analysis. The debittered *moringa* seed flour was divided into two portions. One portion was packed in polypropylene bags, kept in airtight container and stored at 4 °C prior to analyses, while the remaining portion was used for the subsequent preparation of another sample batch.

2.2.3 Debittered-fermented *moringa* seed flour

Debittered-fermented *moringa* seed flour was prepared according to the method described by Villacres *et al.* (2020) and Chinma *et al.* (2020). Briefly, 1 g of dry yeast (*S. cerevisiae*) was mixed with 65 mL distilled water and the suspension was poured into 100 g DMOSF and gently mixed for 5 min. Afterwards, the mixture was covered with aluminum foil and fermented at 28 °C for 16 h in a fermentation cabinet (National MEG Company, Lincoln, USA). The fermented batter was oven dried (Gallenkamp, Cheshire, UK) for 24 h at 40 °C. The dried meal was blended and sieved (100 µm mesh sieve) to obtain debittered-fermented *moringa* seed flour (DFMOSF). The DFMOSF was packed in polypropylene bags, kept in airtight container and stored at 4 °C prior to analyses.

2.3 Analysis of antinutritional factors (ANFs)

Phytic acid and tannin content were assayed as described by AOAC (2005). Trypsin inhibitor activity and oxalate content were assayed as reported by Chinma *et al.* (2022). Total nitrates, residual urease activity and total alkaloid were determined as previously described by Villacrés *et al.* (2020).

2.4 Analysis of total phenolic content and antioxidant activities

A methanolic extract (ME) was prepared from the respective samples as described by Chinma *et al.* (2014). Briefly, 0.2 g of sample was mixed with 4 mL 80% methanol (4 mL) and the mixture was centrifuged at 4000 × g for 20 min. Thereafter, the supernatant was transferred into test tubes, evaporated (under nitrogen stream) and stored at 4 °C. The extraction of samples was done in triplicate. The MEs of the samples were used for the analysis of total phenolic content (TPC) and antioxidant activities (except vitamin C). The TPC was determined by the Folin–Ciocalteu reagent method as previously explained by Chinma *et al.* (2014) and expressed as mg GAE/100 g. The ABTS [free radical scavenging 2,2'-azino-bis(3-ethyl-benzthiazoline-6-sulfonic acid)] was determined as explained by Chinma *et al.* (2022) and presented as mg TE/g (dry basis). The DPPH (1,1-diphenyl-2-picryl-hydrazil) radical scavenging activity and ferric reducing antioxidant power (FRAP) were determined as described by Chinma *et al.* (2014) and expressed as mg TE/g. Ascorbic acid (vitamin C) content was assayed using 2,6 dichlorophenol-Indophenol method (AOAC, 2005).

2.5 Statistical analysis

Data analysis was carried out using analysis of variance (ANOVA) with a statistical software (SPSS 20 , BM, Armonk, NY, USA) and Tukey's test was used to determine significant differences (5% probability) among means.

3.0 Results and Discussion

3.1 Effect of debittering, and combined debittering and fermentation on ANFs of moringa seed flours

Table 1 shows the antinutritional composition of raw, debittered and debittered-fermented *moringa* seed flour. The phytic acid (PA) content of raw *moringa* seed recorded in this study is lower compared to the value (78.33 mg/100 g) recorded by Ijarotimi *et al.* (2013). The initial concentration of PA (74.83 mg/100 g) in raw *moringa* seed decreased by 61.65% and 92.85% after debittering, and combined debittering and fermentation treatments, respectively. The decrease in PA content may be ascribed to hydrothermal treatment during debittering (prior to fermentation), and the production of phytase by microbial strains in addition to activation of endogenous phytase during fermentation due to favourable conditions (Yakubu *et al.*, 2022).

Tannin content of the raw *moringa* seed was 268.25 mg/100g which is higher than the value (241.67 mg/100 g) reported by Ijarotimi *et al.* (2013). The tannin content was decreased by 51.32% and 71.24% following debittering, and combined debittering and fermentation treatments, respectively. The significant ($p \leq 0.05$) reduction in tannin content following debittering may partly be attributed to high leaching loss of tannin in cooking water caused by breakdown of protein-tannin complex (Villacres *et al.* 2020) as well as microbial synthesis of tannase during fermentation (Yakubu *et al.*, 2022).

Debittering, and combined debittering and fermentation treatments caused significant ($p \leq 0.05$) reduction in trypsin inhibitors (57.95% and 81.54%, respectively), saponin (57.22% and 86.57%, respectively), total nitrates (92.45% and 93.73%, respectively), urease activity (88.33% and 95.00%, respectively) and total alkaloids (67.49% and 92.93%, respectively) content compared to raw *moringa* seed flour (Table 1), probably due to the effect of heat treatment prior to fermentation, and increased activities of microorganisms during fermentation. It was observed that combined debittering and fermentation treatment had a substantial effect in the reduction of antinutritional factors and improvement of antioxidant activities compared to debittering treatment alone. These results are in agreement with a previous report where debittering, and combined debittering and solid-state fermentation with *Rhizopus oligosporus* caused significant reduction in antinutritional factors in lupin seed flour than the raw flour (Villacrés *et al.*, 2020).

3.2 Effect of debittering, and combined debittering and fermentation on the TPC and antioxidant potential of moringa seed flours

Raw *moringa* seed flour contained 7.22 mg GAE/g, which is close to the value (7.8 mg GAE/g) reported by a previous worker that assayed TPC in raw *moringa* seed using ME (Singh *et al.*, 2013). It was observed that TPC content of the samples was in the order: DFMOSEF > DMOSF > RMOSF. The higher TPC recorded in debittered seeds may be attributed to the effect of hydrothermal treatment during the debittering process in facilitating the extraction of phenolics from the *moringa* seed matrix. On the other hand, the increased TPC following combined debittering and fermentation process, could be ascribed

to activation of the enzymes that enabled the formation of phenolic compounds; thus, the observed significant increase in ABTS, DPPH, FRAP and ascorbic acid content in the processed *moringa* seed flour compared to the raw flour. It has been reported that increased antioxidant activities in foods are usually associated with increased phenolics (Chinma *et al.*, 2021). These results are in agreement with increased TPC and antioxidant properties of debittered, and debittered-fermented lupin seed flours (Villacrés *et al.*, 2020).

4.0 Conclusions

This study demonstrated that debittering, and combined debittering and solid-state fermentation with *S. cerevisiae* significantly ($p \leq 0.05$) decreased the antinutritional factors, increased TPC and antioxidant potential of *moringa* seed flour. The study also established that combined debittering and solid-fermentation caused a substantial reduction in antinutritional factors and improvement in antioxidant potential of *moringa* seed flour than debittering treatment alone. Consequently, the low level of residual antinutrients in *moringa* seed following debittering, and combined debittering and fermentation is expected to improve the nutritional composition of the flour. In view of this, studies are on-going in our laboratory on the impact of debittering alone or in combination with solid-state fermentation on the nutritional composition and techno-functional properties of *moringa* seed flour.

Table 1. Antinutritional composition of raw, debittered, and debittered-fermented *moringa* seed flours

Parameter	Raw flour	Debittered flour	Debittered-fermented flour
Phytic acid (mg/100 g)	74.83±1.05 ^a	28.70±0.34 ^b	9.35±0.10 ^c
Tannin (mg/100 g)	268.25±0.89 ^a	130.59±0.75 ^b	77.16±0.11 ^c
Trypsin inhibitors (TIU/mg sample)	1.95±0.04 ^a	0.82±0.01 ^b	0.36±0.01 ^c
Saponin (mg/100 g)	10.73 ±0.10 ^a	4.59±0.05 ^b	1.44±0.02 ^c
Total nitrates (mg/100 g)	36. 54±0.17 ^h	2.76±0.03 ^a	2.29±0.01 ^a
Urease activity (pH difference)	0.62 ±0.01 ^a	0.09±0.00 ^b	0.05±0.00 ^b
Total alkaloids (mg/100g)	16.55 ±0.13 ^a	5.38±0.09 ^b	1.17±0.12 ^c

The data from triplicate experiments are expressed as a mean ± standard deviation.

Values with different superscripts in a row are significantly different ($p \leq 0.05$).

Table2. Total phenolic content and antioxidant activities of raw, debittered, and debittered-fermented *moringa* seed flours

Parameter	Raw flour	Debittered flour	Debittered-fermented flour
TPC (mg GAE/g)	7.22±0.01 ^c	8.79±0.01 ^b	9.06±0.01 ^a
Vitamin C (mg/100 g)	4.35±0.02 ^c	5.60±0.05 ^b	6.23±0.03 ^a
ABTS (mg/100g)	91.70±0.13 ^c	127.95±0.16 ^b	148.61±0.20 ^a
DPPH (mg TE/g)	2.44 ±0.17 ^c	3.16±0.10 ^b	6.75±0.13 ^a
FRAP (mg TE/g)	3. 15±0.04 ^c	5.38±0.02 ^b	8.10±0.01 ^a

The data from triplicate experiments are expressed as a mean $\pm$ standard deviation.

Values with different superscripts in a row are significantly different ($p \leq 0.05$).

TPC= Total phenolic content, ABTS+ [free radical scavenging 2,2'-azino-bis(3-ethyl-benzthiazoline-6-sulfonic acid)], DPPH (1,1-diphenyl-2-picryl-hydrazil) radical scavenging activity, and FRAP = Ferric reducing antioxidant power.

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EFFECT OF DIFFERENT DRYING METHODS ON THE FUNCTIONAL PROPERTIES OF OKRA MUCILAGE

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Abstract

The present study was undertaken to evaluate the effect of different drying types on the functional properties of mucilage extracted from bark, seed and leaf of okra plants. Okra mucilage (OM) was extracted by precipitation method. Okra pods and seeds were sliced and immersed in water at room temperature. After 12h, with the aid of a muslin cloth, the solid was separated from the liquid fraction (filtrate). The mucilage samples were either oven dried or freeze dried. The dried samples gotten from the foregoing treatments were analysed based on some functional properties: Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), Swelling Index (SI), Bulk density (BD), Foaming Capacity (FC), and Solubility (SB). The results showed that the mucilage extracted from the leaf showed the highest WAC for both treatments with values of 28.65% and 30.43%. Similar trend was recorded in OAC and SI, with the leaf sample showing higher values of 4.71%-7.31% and 58% respectively. Conversely, the mucilage extracted from the seed had superior values in FC (68.65% and 69.95%) for freeze dried and oven dried treatments respectively. The result also showed that solubility for both treatments was highest in the seed (66.37% and 68.53%). Also, the seed had the highest values in bulk density for both treatments (0.83% and 0.86%). The result showed that the drying methods used impacted more on the mucilage extracted from okra seed.

Keywords: *Okra, Mucilage, Freeze drying, Oven drying, Functional properties*

• INTRODUCTION

Okra (*Abelmoschus esculentus*) is a multipurpose crop due to the varied use of its leaves, buds, flowers, pods, stems and seeds. The whole okra plant is edible and has various food, non-food and medical applications (Adelakunet *al.*, 2009). The seed is nutritionally the richest part of the okra plant (Adelakunet *al.*, 2009). Influence of pre-treatment on yield chemical and antioxidant properties of a Nigerian okra seed (*Abelmoschus esculentus*) flour. The plant is made up of fruit, leaves, stem, and a mucilaginous material that has several food and medicinal uses. Some applications of okra in the food Industry include the following: Okra powder has been used successfully as an emulsifying agent in mayonnaise and salad dressing where it acts as a protective colloid to preserve emulsion integrity, as a stabilizer, okra prevents the undesirable formation of ice crystals in ice cream and sherbets, in cheese spreads, okra gum acts as an emulsifier, which makes it possible to add water to make a

creamy, smooth spread, In confectionery, okra is used in the formulation of fondants, frostings, sauces, etc.

“Okra mucilage has been subject to limited studies as a hydrocolloid, hence, necessitating the need to explore its inherent properties. Okra” mucilage refers to the thick and slimy substance found in fresh as well as dried pods. Mucilaginous substances are usually concentrated in the pod walls and are chemically acidic polysaccharides associated with proteins and minerals.

Okra mucilage has potential for use as food, non-food products, and medicine. Food application include use as a whipping agent for reconstituted egg white, as an additive in the formulation of flour-based adhesives, and as an additive in India for clarifying sugarcane juice.

The objective of this study is to determine the effect of different drying methods on the functional properties of mucilage extracted from bark, stem and seed of okra.

2.0 MATERIALS AND METHODS

2.1 Materials

Okra (Bark, Leaf and Seed) was gotten from Kure Ultra-modern Market, Minna, Niger State of Nigeria.

2.2 Preparation of samples

Okra mucilage (OM) was extracted by precipitation method. Okra pods and seeds were sliced and immersed in water at 25°C. After 12h, with the aid of a muslin cloth, the solid was separated from the liquid fraction (filtrate). Three volumes of ethanol was added to the filtrate and the liquid slowly stirred by hand until mucilage was precipitated. The mucilage was divided into two portions, one part was freeze dried at -38°C, and the other portion was oven dried at 80°C for 48h. It was then pulverized to a fine powder with the aid of a blender and passed through sieves (mesh 100 and mesh 325). The resultant fine powder was stored in an amber recipient until the moment of use.

2.3 Determination of functional properties

2.3.1 Water absorption capacity (WAC) measurement

The WAC of mucilage was determined according to the method used by (Sciarini *et al.*, 2009). About 0.5 g of the sample was weighed in a tube and distilled water was added up to about half of the tube so that the sample is completely wet while it was ensured that extra water was in the system. The dispersion was stirred in a closed tube for 16 h to allow the sample to

absorb enough water and then it was centrifuged at $1600\times g$ for 10 min at ambient temperature. After discharging the supernatant solution, the swollen sample was weighed again, and the water absorption capacity was calculated using the following equation:

$$WAC = \frac{\text{swollen sample weight} - \text{sample weight}}{\text{sample weight}} \times 100 \quad (i)$$

2.3.2 Solubility determination

Solubility of mucilage was determined according to the method used by (Sciarini *et al.*, 2009). 1% (w/w) gum suspension was prepared in distilled water, and 30 mL of this suspension was heated in the water bath at 30, 60, 70, and 90 °C for 30 min. During this time, the mixture was continuously stirred. The tubes was stirred further for 2 h at 25 °C by a roller mixer. The sample was centrifuged at $800\times g$ for 15 min and 10 mL of the supernatant will be dried in an oven at 105°C overnight until a constant weight is achieved.

$$\text{Solubility} = \frac{(\text{final weight} - \text{initial weight}) \times 30}{10} \times 100 \quad (ii)$$

2.3.3 Swelling index

One gram of mucilage was placed into a 25mL glass Stoppard measuring cylinder. 25mL of water was added into the cylinder containing mucilage and mixture was shook thoroughly at interval of every 10min for one hour. The sample was allowed to stand for three hours at room temperature and volume occupied by extract was measured. The mean value was calculated related to one gram of mucilage extract (Uzma *et al.*, 2013; Ikon *et al.*, 2010).

2.3.4 Foaming capacity

Foaming capacity was determined following the method described by Jahanbin (2012). 1 g each of Okro extract (seed, pod and bark) were added to 100ml of distilled water, then strong agitation was applied for 5 mins. Foaming Capacity was calculated according to the following equation:

$$\%FC = \frac{\text{Volume after Agitation} - \text{Volume before}}{\text{Volume before agitation}} \times 100 \quad (iii)$$

2.3.5 Bulk Density

Bulk density was determined by the method used by Asoegwu *et al.* (2006). 50g of okro

extract was weighed on a bench until a constant volume was observed. The packed volume was recorded. The bulk density (BD) was calculated by using a ratio of sample weight to constant volume obtained as

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Constant volume}} \quad (\text{iv})$$

2.3.6 Oil Absorption Capacity

Oil Absorption Capacity was determined by the method described by Aremuet *al.* (2007). One gram of okro extract was mixed with 10ml of soybean oil in a centrifuge tube and allowed to stand at room temperature for one hour. It was then centrifuged at 200rpm for 30 minutes and the supernatant was transferred into a 10ml graduated cylinder.

$$\text{OAC} = \frac{\text{swollen sample weight} - \text{sample weight}}{\text{sample weight}} \times 100 \quad (\text{v})$$

	FDB	FDS	FDL	OVB	OVS	OVL
WAC	21.70 ^c ±0.04	20.15 ^b ±0.03	28.65 ^b ±0.23	26.20 ^c ±0.04	23.45 ^b ±0.31	30.43 ^b ±0.20
OAC	3.00 ^b ±0.00	2.50 ^a ±0.10	4.75 ^a ±0.02	2.99 ^b ±0.01	2.75 ^a ±0.05	7.31 ^a ±0.01
Bulk Density	0.71 ^a ±0.00	0.83 ^d ±0.00	0.65 ^c ±0.01	0.84 ^a ±0.00	0.86 ^d ±0.00	0.68 ^c ±0.01
Foaming Capacity	42.45 ^c ±0.12	68.65 ^d ±0.65	48.24 ^b ±0.27	44.00 ^c ±0.00	69.95 ^d ±0.08	50.58 ^b ±0.14
Solubility Swelling Index	63.20 ^b ±0.20	68.53 ^c ±0.19	60.16 ^a ±0.02	68.25 ^b ±0.02	66.37 ^c ±0.03	60.47 ^a ±0.09
	42.02 ^a ±0.04	52.33 ^b ±0.22	58.49 ^c ±0.16	43.15 ^a ±0.03	54.43 ^b ±0.19	57.99 ^c ±0.05

KEYS: **FDB**= Freeze dried okra bark mucilage, **FDS**= Freeze dried okra seed mucilage, **FDL**= Freeze dried okra leaves mucilage, **OVB**= oven dried okra bark mucilage, **OVS**= oven dried okra seed mucilage, **OVL**= oven dried okra leaves mucilage; **OAC**= Oil absorption capacity, **WAC**= water absorption capacity.

3.0 RESULT AND DISCUSSION

The results showed that the drying methods have significant effect on the water absorption capacity (WAC) of the various samples. Samples were significantly different from each other at $p \leq 0.05$. with the freeze dried seed (FDS) recording the lowest and oven dried leaf (OVL) the highest. WAC is critical property in food technology for stability, yield, texture, and sensory evaluation. The amount of water held and absorbed by the hydrated sample after an external force is applied is represented by its water absorption capacity. It was also observed that as the temperature of drying increases (i.e from freeze drying which is low temperature

drying to oven drying which relatively high temperature drying), the ability of the mucilage to absorb water increases. This is in line with the work reported by Alpizar-Reyes *et al.* (2017).

There is also similar trend in terms of oil absorption capacity (OAC). The OAC are significantly different from each other at $p \leq 0.05$. The OAC increased with increasing temperature, possibly because the availability of nonpolar chains increases with increasing molecular mobility, which may bind the oil's hydrocarbon units (Amid and Mirhosseini, 2012). Furthermore, it could be influenced by pore size, which has been shown to increase with increasing temperature (Alpizar-Reyes *et al.*, 2017), allowing for greater fat entrapment (Ghribiet *al.*, 2015). Because fat acts on flavour retainers and increases the mouth feel of foods, these OAC values suggest that Okra mucilage could play an important role in food processing.

The bulk density of the samples were significantly different at $p \leq 0.05$. The results shows that the oven dried mucilage were relatively higher than the freeze dried mucilage. This behaviour may be attributed to higher drying rate. The higher the drying rate, the lower the bulk densities due to the presence of water. Higher moisture content will increase the bulk density (León-Martínez *et al.* 2010). It is however important to note that, the bulk densities were higher in FDS and OVS (freeze dried mucilage from Okra seed and oven dried mucilage from okra seed).

Foaming capacity of the different samples were significantly different from each other at $p \leq 0.05$. The oven dried samples were significantly higher than those of the freeze dried samples. Mucilage foaming capacity (FC) and foam stability (FS) are affected by a variety of factors, including protein and carbohydrate content, molecular weight, structure, and the presence of additional compounds in the hydrocolloid (Mahfoudhiet *al.*, 2014). A flexible mucilage structure that can reduce surface tension is linked to good foaming properties.

The various mucilage samples were significantly different at $p \leq 0.05$ as shown in the table above in terms of solubility. Solubility is an important factor to consider in food systems because it influences other functional properties and provides an indication of how well hydrocolloids perform in dispersion systems. The interaction of hydrocolloids with water molecules reduces diffusion and stabilizes hydrocolloid presence in water. Meanwhile, the swelling index of the samples were significantly different at $p \leq 0.05$. There is relative increase in swelling index due to high temperature drying medium. This is in line with the report of Alpizar-Reyes *et al.* (2017). The swelling index was higher in the oven dried mucilage compared to that of the freeze dried mucilage. The swelling index indicates the level of granule hydration. As a result, high swelling capacity indicates weaker binding forces in the granules. Increased temperature causes weaker binding interactions between mucilage molecules, resulting in mucilage chain enlargement and increased water molecule entrapment (Alpizar-Reyes *et al.*, 2017).

Conclusion: From the study, dried mucilage showed significant variations in functional parameters from the wet mucilage. The dried mucilage extracts show greater stability than the wet mucilage.

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CHEMICAL, ANTI-NUTRITIONAL AND SENSORY ATTRIBUTES OF PUMPKIN SEED (*TELFAIRIA OCCIDENTALIS*) ENRICHED PLANTAIN

(*Musa spp.*) Snacks (*Dodo-ikire*)

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ABSTRACT

Dodo- Ikire was produced from blends of plantain and fluted pumpkin seed flour. Plantain and pumpkin seed flours were blended in ratios 100:00, 99:1, 98:2, 97:3, 96:4 and 95:5 respectively. Addition of fluted pumpkin seed flour increased the protein content (3.65-7.91%), ash (3.26- 4.47%), fibre (1.71%-2.10%), fat (12.43-13.68%), Iron (0.25-0.39%), phosphorus (5.97-6.99%), vitamin C (12.96-18.93%) vitamin. A (5.26%- 5.66%) and the antinutrients contents of the products. The product samples were not significantly different ($P<0.05$) in terms of appearance, aroma, texture, chewiness and general acceptability. In terms of general acceptability, sample with 5% pumpkin seed flour was the most preferred sample. Enrichment of dodo-Ikire with fluted-pumpkin seed flour increased the protein, fat, fibre,, mineral (iron and phosphorus) and vitamins (vitamin A and C) of the product and the formulations were acceptable to the consumers.

Key words: Dodo- Ikire, Chemical compositions, Fluted pumpkin, Anti nutrients, Sensory qualities

Introduction

Dodo-Ikire is a plantain snack made from overripe plantain, salt, onion, pepper etc. Naturally occurring antioxidant could be added to prolong the shelf life (Pourmorad et al., 2006). Fluted pumpkin seed has high protein content and appreciable levels of phosphorus, vits A and C (Odiaka et al., 2008). The aim of this research is to produce *Dodo Ikire* from plantain blended with pumpkin seed flour to improve its nutritional qualities.

Materials and methods:

Matured plantain and fresh fluted pumpkin (*Telfairia occidentalis* Hooks) were procured from an open market in Ibadan. Chemical reagents used were of analytical grade obtained from Food Science and Technology Program me of the College of Agriculture, Engineering and Science, Bowen University, Iwo.

Preparation of Samples

Fluted pumpkin flour was made from fluted pumpkin seeds; intact seeds coats were boiled in a covered stainless-steel pot for one hour. The cooked seeks were dehulled manually and dried at 50°C. Dried dehulled seeds were ground using a laboratory mill and screened through a 0.25mm British Standard Sieve, packaged in polythene bags and stored in refrigerator until used.

Preparation of *Dodo-Ikire*

Overripe plantain was mashed, salt, pepper and onions were added and mixed together.

Seven samples were produced from blends of plantain and pumpkin seeds flour in ratios: 100:0, 99:1; 98:2, 97:3, 96:4 and 95:5 respectively. A commercial product was obtained in the market as a standard to make seventh sample. The blends were molded into shape and fried in a hot palm oil until it turned black or almost burnt.

Analyses of Samples

Proximate analyses were carried out using the Official Methods of AOAC, (2020). Essential minerals elements were determined using, the methods described by Fashakin et al., (1991). Vitamins A. and C were determined using the method of AOAC (2020).

Determination of Anti Nutrients:

Tannin contents were determined using the method described by Price et al., (1978).

Determination of saponin, oxalate and phytate contents were carried out using the methods described by Brunner (1984).

Sensory Analysis

Sensory evaluation of product samples was conducted using multiple comparison tests (Larmond, 1977). A panel of 11 judges assessed the *Dodo-Ikire* samples based on taste, appearance, aroma and overall acceptability. The samples were scored using a 5-point hedonic scale. The scores were subjected to analysis of variance (ANOVA) using SPSS (version 20) and Duncan Multiple Range Test to separate the means.

RESULT AND DISCUSSION

Proximate Analysis

Table 1: Chemical Composition of Pumpkin Seed Enriched Plantain Snacks (*Dodo Ikire*)
Ratio of Blending (Pumpkin Seed: Plantain)

Parameter	0:100	1:99	2:98	3:97	4:96	5:95	Market Sample
Moisture(%)	8.53±0.02 _b	9.22±0.56 ^a	8.98±0.03 ^a	9.02±0.01 ^a	8.89±0.10 ^a _b	9.06±0.04 ^a	8.87±0.27 ^a _b
Crude Fat(%)	12.43±0.0 _{4d}	12.99±0.02 _{bc}	13.01±0.01 _b	13.10±0.09 _b	13.64±0.02 _a	13.68±0.0 _{6a}	12.86±0.1 _{6d}
Crude Fibre(%)	1.73±0.02 ^f	1.78±0.02 ^c	1.95±0.01 ^c	2.10±0.02 ^a	2.06±0.02 ^b	2.10±0.02 ^a	1.71±0.07 ^f
Ash(%)	3.26±0.04 ^f	3.61±0.64 ^e	3.83±0.25 ^d	3.96±0.02 ^c	4.19±0.04 ^b	4.47±0.11 ^a	3.27±0.05 ^f
Crude Protein(%)	3.83±0.11 ^f	4.25±0.07 ^c	5.84±0.06 ^d	6.84±0.06 ^c	7.40±0.05 ^b	7.94±0.06 ^a	3.65±0.10 ^g
CHO(%)	70.20±0.1 _{2a}	68.13±0.58 _b	66.42±0.19 _{ab}	65.07±0.03 _{ab}	63.81±0.11 _{ab}	44.09±2.5 _{4b}	69.62±0.3 _{5a}
Vit. A(%)	5.26±0.11 ^a	5.45±0.12 ^d	5.47±0.11 ^d	5.53±0.11 ^c	5.62±0.11 ^b	5.66±0.11 ^a	5.26±0.11 ^c
Vit. C(%)	13.03±0.1 _{8c}	13.84±0.08 _d	13.95±0.17 _d	15.78±0.27 _c	17.81±0.15 _b	18.93±0.1 _{0a}	12.96±0.1 _{5c}
Iron(mg/100g)	0.26±0.00 ^f	0.28±0.00 ^c	0.29±0.01 ^d	0.31±0.00 ^c	0.34±0.00 ^b	0.39±0.00 ^a	0.26±0.00 ^f
Phosphorus(mg/100g)	6.00±0.02 ^c	6.05±0.03 ^d	6.12±0.01 ^c	6.14±0.01 ^c	6.43±0.07 ^b	6.99±0.04 ^a	5.97±0.01 ^c
Oxalate(%)	1.00±0.03 ^c	1.05±0.02 ^c	1.10±0.04 ^c	1.13±0.20 ^c	1.20±0.07 ^b	1.63±0.20 ^a	1.00±0.21 ^c
Phytate(%)	2.91±0.60 ^c	3.19±0.02 ^c	3.22±0.01 ^c	3.24±0.01 ^b	3.27±0.01 ^b	3.28±0.01 ^a	3.04±0.01 ^c
Saponin(%)	0.14±0.00 ^c	0.15±0.00 ^d _e	0.14±0.00 ^c _d	0.15±0.01 ^b _c	0.16±0.00 ^a _b	0.15±0.00 ^a	0.14±0.00 _{de}
Trypsin(%)	0.67±0.00 ^c	0.67±0.00 ^c	0.69±0.01 ^d	0.70±0.00 ^c	0.76±0.00 ^b	0.84±0.00 ^a	0.67±0.00 ^c

*Values represent mean ±3 Standard Deviations

*Values with different superscripts along the row are significantly different from each other. Addition of fluted pumpkin seed flour increased the protein (3.65-7.91%), ash (3.26-4.47%), fibre (1.71-2.10%), fat (12.43-13.68%), Iron (0.25-0.39%), phosphorus (5.97-6.99%), vit. C (12.96-18.93%), vit. A (5.26-5.66%) and the anti-nutrients contents of the products. Heat treatment reduced the anti-nutrient contents to a safe level (Table 1).

Table 2: Sensory Evaluation of Fluted Pumpkin Seed Enriched Plantain Snacks (Dodo Ikire)
Ratio of Blending (Pumpkin Seed: Plantain)

Parameter:	3:64	1:99	2:98	3:97	4:96	5:95	Market Sample
Appearance	1.45±0.69 _b	1.45±0.52 _b	1.55±0.52 _b	1.73±0.79 _b	1.36±0.51 _b	2.00±1.00 _b	3.36±0.24 ^a
Texture	1.45±0.52 _{bc}	1.45±0.52 _{bc}	1.18±0.41 _c	2.91±0.94 _a	1.91±0.14 _a	3.27±0.65 _a	3.00±0.45 ^a
Chewiness	2.36±1.03 _a	2.82±1.08 _a	2.82±1.25 ^a	2.18±0.60 _a	2.18±1.25 _a	2.55±1.21 _a	2.91±1.38 ^a
Taste	3.64±0.81 _{ab}	2.91±0.70 _b	3.275±1.00 ^b	3.73±1.49 _{ab}	3.45±0.82 _{ab}	3.28±0.75 _{ab}	4.36±1.03 ^a
Aroma	2.64±1.11 _{2c}	3.00±0.89 _{bc}	4.18±1.17 ^a	3.73±0.79 _{ab}	3.73±0.79 _{ab}	4.18±1.17 _a	4.36±1.03 ^a
General Acceptability	3.64±0.92 _{ab}	3.27±1.19 _b	3.00±1.00 _b	3.73±1.35 _{ab}	3.55±0.93 _{ab}	3.91±0.8 ^a _b	4.36±1.03 ^a

*Values represent mean ±3 Standard Deviations

*Values with different superscripts along the row are significantly different from each other. Table 2 gave the results of sensory evaluation. The commercial sample had the highest rating of 4.36 in terms of general acceptability. Enriched *dodo-ikire* formulated with 5% and 3% had the next highest rating, ranging from 3.73 to 3.9, while sample containing 1% fluted pumpkin had the lowest. The result showed that dodo-Ikire enriched with fluted-pumpkin seed was acceptable to consumers. Fat acts as a flavor retainer and helps to improve sensory properties of foods such as dodo-ikire.

Conclusion

Enrichment of dodo-Ikire with fluted-pumpkin seed flour increased the protein, fat, fibre, mineral (iron and phosphorus) and vitamins (vitamin A and C) of the product and the formulations were acceptable to the consumers.

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PHYSICOCHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF JAM PRODUCED FROM CARROT AND DATE FRUIT BLENDS

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Abstract

The physicochemical properties and sensory attributes of jam produced from carrot and date fruit at different proportions were investigated which ranged from 100% carrot jam 90/10%, 80/20%, 70/30%, 60/40%, 50/50%. Standard procedures were used for the evaluation. The physicochemical result showed an increase in value as the date composition increased in the jam produced. For ascorbic acid it ranged 0.25 to 0.59 AMA (100% carrot jam) to GAMA (50% carrot/50% date) 3.80 to 5.00 AMA (100% carrot jam) to FAMA (60% carrot/40% date) for pH and 64.63 to 76.17 AMA to GAMA), total soluble solids. The total titratable acidity ranged 1.43 to 2.37 with GAMA having the least value and AMA having the highest value, the acidity of the jam decreased as the concentration of the date pulp was increasing. All the samples were rated well for sensory evaluation with sample DAMA (70 Carrot /30 dates) being judged the best with values 7.03 texture 7.10 taste 7.30 colour 6.93 flavor 6.97 aroma and 7.60 overall acceptability. Jam production from carrot will help reduce post-harvest losses and also increase the utilization of date fruit in industries.

Keywords: Carrot, Jam, Date fruits

INTRODUCTION

Jam is a semi-solid food product, obtained upon cooking of fruits and vegetables pulp with sugar, citric acid and pectin (Ullah *et al.*, 2018), Jam is said to be an intermediate moisture food, with more than 65% total soluble solid. Sugar constitutes more than 40% of total weight and 80% of total solid in jam (AOAC, 2012). There are two varieties of jam, those produced from a single fruit and those produced from more than one fruit (varieties of fruit pulp). A good jam must have a soft and even consistency without distinct pieces of fruit, a bright color, good flavor and a semi-jelled texture that is easy to spread but has no free liquid, (Makanjuola and Alokun, 2019). Jam is part of the most used product in consumption of bread.

Carrot (*Daucus carota*) is a globally important root vegetable crop that provides essential bioactive constituents such as carotenoids, anthocyanin and other phenolic compounds, they supply significant amount of dietary vitamin A intake through alpha and Beta carotene. The B vitamins including thiamin, riboflavin, niacin, pantothenic acid, folate and vitamin B6 are found in carrot in appreciable quantities when compared with other commonly consumed vegetables (Anjum *et al.*, 2000). Due to the presence of these compounds carrot is considered as a functional food with potential health benefits for human. Carotenoids are well known as important micronutrients for human health due to their antioxidant properties. (Jawaheer *et*

al., 2003).

Date fruit (*Phoenix dactylifera*) is a stone fruit; it has a single seed surrounded by an outer fleshy fruit (like peaches, mangoes, and olives). They are grown on date palm trees. It is one of the most abundant fruits in the world with hundreds of varieties, having different texture, colour and flavors. They are known to contain high level and wide range of phenolic antioxidant and fiber. (Ghnmi *et al.*, 2017). Overproduction of dates with limited processing has led to a major loss which is as high as 2 million tons per year, which is being observed during harvest, storage, processing etc. (Besbes *et al.*, 2009).

The food industry is facing the challenge of developing new food products with special health enhancing characteristics. Therefore, this study is posed to contribute to the work of many scholars to develop a food product which is not only safe but also nutritious and can be able to meet the daily nutritional needs of individuals and not predispose the consumers to health hazards or complications. The aim of this work is to produce jam using carrot and date fruits, to ascertain physicochemical properties and sensory attributes of the product obtained.

Materials and Methods

Carrots (*Daucus carota*) and date fruits (*Phoenix dactylifera*) were purchased from Arigbajo local market, Ifo, Ogun State, Nigeria. Pectin was obtained from Mekang laboratory, Okota, Lagos State, citric acid was from Libertous laboratory Abeokuta, jars used for packaging were procured from Sango Ota, Ogun State.

2.1 Sample preparation

Carrots were sorted, washed and scrapped to remove adhering soil and dirt, while the date fruits were sorted, washed and sliced to remove seeds. The date slices were dipped in water containing 1% citric acid to avoid oxidation while carrots were boiled in water for softness. The carrot was blended, so also date fruit, in order to get the pulp. Carrot and date fruits were combined in 6 different proportions for jam preparation. (Awan and Salim-ur-Rehman, 2010). All batches were cooked; 15 mL of pectin and 5g of sugar were added to each of the sample until it formed a reasonable consistency for the jam preparation. The samples were packaged in sterilized 250g glass jar.

Sample Formulation for the jam production include: AMA; 100% carrot, BAMA; 90% carrot: 10% date fruit, CAMA; 80% carrot: 20% date fruit, DAMA; 70% carrot: 30% date fruit, FAMA; 60% carrot: 40% date fruit, GAMA; 50% carrot: 50% date fruit

2.2 Physicochemical analysis

Samples were examined for physicochemical properties which included total soluble solids (TSS), pH, titratable acidity (ITA) and ascorbic acid. Digital refractometer (RFM 700-M, HANNA) was used in determining the total soluble solids using standard method of AOAC (2012), titratable acidity was determined using procedure as recommended by AOAC (2012). pH was determined for the concentration of hydrogen ion with method as described by AOAC (2012) using a pH meter (model BA 350 EDT instruments) after the pH meter was calibrated by adjusting with buffers 4 and 7 solutions. The Ascorbic acid content was determined by the 2, 6

-dichlorophenol indo-phenol titration, procedure (AOAC, 2012)

2.3 Sensory evaluation

Carrot date fruit jam samples were evaluated for sensory characteristics such as color, taste, texture and overall acceptability. Samples were examined by 30 Panelists by using 9 hedonic scales as described by Larmond (1977).

2.4 Statistical analysis

All determinations were performed in duplicate. Normality test (Z for skewness and curtosis Z) were performed for analysis the data. When $p > 0.05$, in two or more of the tests, the distribution was considered normal and the mean and standard deviation were reported. Analysis of variance (ANOVA) was used to determine significant differences among samples. SPSS 23.0 software package (Statistical Package for Social Scientist, Michigan, USA).

3.0 RESULTS AND DISCUSSION

3.1 Physicochemical properties of carrot date jam

Result on physicochemical analysis carried out on quality jam produced from fresh carrot and high quality date fruit are as shown on Table 1. The total soluble solid (TSS) carrot with date fruit jam ranged from 64.63 to 76.17 with 50/50% composition having the highest total soluble solid of 76.17 and the 100% carrot jam having the lowest value of 64.63. Makanjuola and Alokun (2019) stated that TSS should not be less than 68% but AMA (100% carrot) and BAMA (90/10 carrot date jam) had 64.63 and 66.10 respectively. This might be due to little or no use of date in the sample compared to the other sample. It was observed that as the date composition to carrot ratio increased, the value for the TSS increased, this was experienced in the research carried out by Ullah *et al.* (2018). The possible cause of rising of total soluble solids (TSS) can be due to the formation of mono and disaccharides resulting from hydrolysis of polysaccharides (Satkaret *et al.*, 2012).

Carrot with date fruit jam samples titratable acidity (ITA) ranged from 1.43 to 2.37 with the 50/50% Carrot jam having the least 1.43 and 100% carrot jam having the highest 2.37%. The total titratable acid in jam is dependent on the total amount of acid (citric acid) present in the jam produced. This increase in acidity might be due to the formation of organic acids due to degradation of polysaccharides and breaking of pectic bodies. These results agree well with the findings of Wasif *et al.* (2017) who observed an increasing trend in acidity of apple and olive blended jam. The pH content of the product indicates that it would have good keeping quality. This is because food spoiling micro flora thrives where there is adequate moisture (Adegunwa *et al.*, 2015). The pH content of Fruits jam samples ranged from 3.70 to 5.00 with 60/40% having the highest value of pH 5.00 and 90/10% jam having the lowest pH value of 3.70. pH determination is quite important in jam production as it helps to obtain an optimum gel formation during the process of jam production. This observation agrees with previous findings on carrot apple pulp jam (Ullah *et al.*, 2018).

The ascorbic acid content of carrot with date Fruit jam samples ranged from 0.25 to 0.59

with 50/50% having the highest value of 0.59 and 100% carrot jam having the lowest ascorbic acid content of 0.25. It was noted that the ascorbic acid content increased as the date composition increased in the jam produced. The result were similar to findings of Ullah *et al.* (2018) who also reported an increase with the increasing composition of apple pulp being used with carrot for jam production. The application of prolonged heat treatment on fruits such as in jams, can lead to loss of beneficial properties of the citrus fruit, (Ullah *et al.*, 2018). Vitamin C functions as a water soluble antioxidant and is also an effective antioxidant that readily scavenges reactive oxygen species (ROS) and reactive nitrogen species, the recommended dietary allowance (RDA) for vitamin C is 75mg per day for women and 90mg for men (WHO, 2018).

Table 1: Physicochemical properties of carrot date jam

SAMPLE	TTA(%)	ASCORBIC(%)	pH	TOTAL SOLUBLE SUGAR(%)
AMA	2.37±0.06 ^d	0.25±0.00 ^a	3.80±0.00	64.63±1.29 ^a
BAMA	2.30±0.10 ^{cd}	0.31±0.01 ^b	3.70±0.00	66.10±1.00 ^a
CAMA	2.13±0.06 ^c	0.33±0.00 ^c	4.30±0.00	68.23±0.75 ^b
DAMA	1.90±0.10 ^b	0.39±0.01 ^d	4.40±0.00	69.70±0.17 ^b
FAMA	1.73±0.15 ^b	0.43±0.01 ^c	5.00±0.00	72.87±0.67 ^c
GAMA	1.43±0.12 ^a	0.59±0.00 ^f	4.90±0.00	76.17±0.21 ^d

Mean values with different superscripts within the same column are significantly different ($p < 0.05$). Where: AMA=100%, BAMA=90/10%, CAMA=80/20%, DAMA=70/30%, FAMA=60/40%, GAMA=50/50%

3.2 Sensory Evaluation

Sensory evaluation was carried by 30 panelist who judged the sample based on color, flavor, consistency, taste and overall acceptability using the 9-point hedonic scale, with 9 means likeextremely, 8 mean like very much, 7 means like moderately, 6 means like slightly, 5 means neither like nor dislike, 4 means dislike slightly, 3 means dislike moderately, 2 means dislike very much and 1 means dislike extremely. Color change was observed from orange to brown colour as the date composition increased. Although no significant difference was observed in the texture, taste, colour and aroma properties of the jam produced amongst the samples as shown on table 2, sample DAMA was rated the highest for colour (7.30 ± 1.317), aroma (6.97 ± 1.189), texture (7.03 ± 1.402) and overall acceptability (7.60 ± 0.855), while sample BAMA was judged the best in terms of taste (7.20 ± 1.21) and flavour (7.10 ± 1.155). On the contrary, sample AMA (100% carrot jam) was rated the least for color (6.63 ± 1.098), aroma (6.27 ± 1.143) and taste (6.60 ± 1.303) this might be as a result of the varied colour, aroma and taste as it is 100% carrot without date. The jam product with 70/30% (DAMA) carrot date fruit was found to be judged the best by the panelist amongst other samples.

Table 2: Sensory evaluation of carrot jam produced from composition of carrot and

high quality date Fruits.

SAMPLE S	TEXTURE	TASTE	COLOUR	FLAVOR	AROMA	OVERALL
AMA	7.03±1.129 ^a	6.60±1.303 ^a	6.63±1.098 ^a	6.93±1.112 ^{ab}	6.27±1.143 ^a	7.07±1.143 ^{ab}
BAMA	6.80±1.243 ^a	7.20±1.215 ^a	7.17±1.177 ^a	7.10±1.155 ^a	6.83±1.464 ^a	7.37±1.159 ^{ab}
	6.80±1.349 ^a	6.43±1.960 ^a	6.97±1.245 ^a	6.37±1.217 ^b	6.63±1.402 ^a	6.97±1.402 ^{ab}
CAMA	7.03±1.402 ^a	7.10±1.423 ^a	7.30±1.317 ^a	6.93±1.230 ^{ab}	6.97±1.189 ^a	7.60±0.855 ^a
DAMA	6.83±1.234 ^a	6.77±1.006 ^a	6.83±1.085 ^a	7.00±0.910 ^{ab}	6.70±1.119 ^a	7.13±1.008 ^{ab}
FAMA	6.90±0.960 ^a	6.67±1.422 ^a	6.83±1.085 ^a	6.73±1.258 ^{ab}	6.33±1.295 ^a	6.93±1.258 ^b
GAMA						

Mean values with different superscripts within the same column are significantly different (p<0.05).

Where: MA=100%: BAMA=90/10%: CAMA=80/20%,: DAMA=70/30%:
FAMA=60/40%: GAMA=50/50%

CONCLUSION

The study has shown that different recipes had a significant impact on the physicochemical properties and sensory attributes of jam produced from carrots and date fruit pulps. Production of jam can easily be carried out without the need for excessive use of sugar using simple domestic method. All the samples were rated well with sample DAMA (70 carrot /30 date) being judged the best based on sensory attributes using the hedonic scale. Results obtained for the physicochemical properties of the jam were in line with previous researches done on jam. Utilization of date fruit in jam production and commercialization of carrot date fruit jam is therefore recommended in order to minimize post-harvest losses encountered as a result of perishability of carrot.

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EFFECT OF SOAKING TIME ON THE YIELD AND FUNCTIONAL PROPERTIES OF *CISSUSPOPULNEA* (OKOHO) MUCILAGE EXTRACT

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Abstract

The present study was carried out to assess the effect of soaking time on the yield and also different drying methods on the functional properties of *Cissuspopulnea* (Okoho) mucilage. The stems were scraped with knife to remove the natural powdery ash that coats them. Dry-cleaned sample was washed in water and cut into pieces 30 cm long. One kg each of the cut pieces was finely reduced into strips of threads and soaked in 6000 mL of water (2000 mL for each kg of sample) at 80–90°C, and allowed to soak in a beaker, accompanied by stirring with a wooden rod, for 10–15 min. The sample was allowed to stand for 24, 48, and 72 hours respectively. At the expiration of the soaking times, the strips were squeezed to the extent possible, so as to release long strands of opaque mucilaginous exudates. The results showed that soaking time had effect on the yield of mucilage. The mucilage was subjected to freeze drying and oven drying, which had significant ($p < 0.05$) effect on the functional properties analysed. The oven dried sample analysed gave higher values for water absorption capacity (22.65%), solubility (68.52%), and bulk density (0.88%), while the freeze dried sample gave higher oil absorption capacity (2.85%) and swelling index (47.84%). The results showed that the drying methods used impacted greatly on the inherent functional properties of the mucilage, which is would find useful applications in food systems

Keywords: *Cissuspopulnea*, Okoho, Mucilage, Soaking, Freeze drying, Oven drying, Functional properties

1.0 INTRODUCTION

Cissuspopulnea belongs to the family of *Amplidacea* (vitacea), which are woody climbers, sometimes vines, rarely small succulent's trees, and hermaphrodite or polygamoneacious to polygamodroecious. *Cissuspopulnea* grows in diverse ecozones of Nigeria, Uganda, Niger Republic, Cameroon and Cote d'Ivoire (Geldam, 2000). The plant is climbing stem, widely distributed in many parts of Nigeria, especially within the guinea savannah region of Anambra, Kogi and Benue States (Alpha *et. al.*, 2003). The Igala and Idoma ethnic groups refer to this plant as *Okoho*, Yorubas as *Ogholo*, and Hausas as *dafaaraa*. It is used extensively in medicinal preparation in West Africa. Thickening agents from plants such as melon, beni seed, *Ogbono*, *Okoro* and *Okoho* (*Cissuspopulnea*) are used to thicken soups in different parts of Nigeria. All part of *Cissuspopulnea* exudes, a mucilaginous material which is traditionally utilized as food raw material. Gum exudates are mainly obtained from the stem and root of the plant.

Cissus gum's demulcent property, biocompatibility, low cost, lack of toxicity, calming action, and non-irritant nature make it ideal for use in a variety of sectors. Its viscous property allows it to be used as a hydrocolloid and soup thickener in the food industry, as well as for its gelling/thickening properties in the production of jam, jelly, marmalades, dairy products,

and salad dressings, and its binding/coating properties in the production of baked foods (Owuno *et al.*, 2012).

Plant mucilages are polysaccharide-rich hydrophilic hydrogels with diverse functions. The exact composition of plant mucilages varies greatly between species and within species' tissue types. Extruded seed mucilages (ESMs) are arguably the well-studied mucilages. They are primarily composed of plant polysaccharides (pectic, cellulosic, and non-cellulosic polymers) with a minor protein component (Tsai *et al.*, 2017). Mucilage is a viscoelastic, high-molecular-weight substance produced by plants (Sasse *et al.*, 2018). Mucilage is primarily composed of polysaccharides, but it also contains proteins, minerals, and lipids (Koochek *et al.*, 2013; Alizedeh Behbahani *et al.*, 2017; Amicucci *et al.*, 2019) which is secreted by roots, seeds, leaves, and stems, depending on the plant species (Galloway *et al.*, 2020).

Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein (Siddiq *et al.*, 2009).

The objective of this study was to assess the effect of different drying methods on the functional properties of *Cissus populnea* extract.

2.0 MATERIALS AND METHODS

2.1 Materials

Cissus populnea stems were gotten from Lokoja International Market, Lokoja, Kogi State, Nigeria.

2.2 Preparation of samples

Cissus populnea stems were scraped with knife to remove the natural powdery ash that coats them. Dry-cleaned samples were washed in water and cut into pieces 30 cm long. For the samples to be used to determine effect of soaking time on yield of mucilage, one kg each of the cut pieces were finely reduced into strips of threads in 6000 ml of water (2000 ml for each kg of sample) at 80–90°C, and allowed to soak in a beaker, accompanied by stirring with a wooden rod, for 10–15 min. The samples were allowed to stand for 24, 48, and 72 hours respectively, after which the quantity gotten for each duration was measured. However, for the sample to be freeze dried and oven dried, and subsequent analyses, the 'Okobo' strips were squeezed to the extent possible, so as to release long strands of opaque mucilaginous exudates. The exudates were filtered through a muslin cloth. 1000 mL of mucilage was gotten. 500 ml of ethanol was added to the mucilage to separate inherent water and other particles from the mucilage. The mucilage was then subjected to two drying methods (Freeze drying and Oven drying).

2.3 Determination of functional properties.

2.3.1 Determination of Water and Oil Absorption Capacities.

Water absorption capacity was determined using the method described by Falade and Okafor

(2015). Sample of (1 g) each (freeze dried, oven dried and liquid sample) were weighed into a calibrated 25 mL conical centrifuge tube. The weight of centrifuge tube and content was taken and recorded. 10 mL of distilled water and 10 mL of groundnut oil was added into centrifuge tubes for both water absorption and oil absorption capacities respectively. The mixtures were made to stand at room temperature ($28 \pm 2^\circ\text{C}$) for 30 minutes. Centrifugation at 400rpm for 20 minutes on an Eppendorf Centrifuge (Model No. 5810R, Gaithersburg, USA) followed subsequently. The liquid was separated from the sediment after centrifugation and then the sample was reweighed. The water absorption capacity and oil absorption capacity were recorded in g/g as;

$$WAC \text{ or } AOC = \frac{\text{Weight of the tube after centrifugation (g)} - \text{initial weight of the tube (g)}}{\text{weight of sample (g)}}$$

(i)

2.3.2 Determination of Bulk Density

The bulk density of each of the extracts (freeze dried, oven dried and liquid sample) was determined according to the method of Onwuka (2005). One (1) g of extract from the three samples (freeze dried, oven dried and liquid sample) were measured into a cylinder and tapped continually until there was no noticeable change in volume. The volumes before and after tapping the cylinder were taken note of and the difference in the bulk density was recorded in g/mL as;

Bulk Density

$$= \frac{\text{weight of Sample (g)}}{\text{Volume of sample before tapping (mL) - volume after tapping (mL)}} \quad (ii)$$

2.3.3 Determination of Foaming Capacity

Foaming capacity was determined following the method described by Jahanbin (2012). One (1) g each of 'Okoko' extract (freeze dried, oven dried and liquid sample) were added to 100mL of distilled water separately, then strong agitation was applied for 5 min. Foaming Capacity was calculated according to the following equation:

$$\% FC = \frac{\text{mL after agitation} - \text{mL before agitation}}{\text{mL before agitation}} \times 100 \quad (iii)$$

2.3.4 Determination of Solubility Hi

To measure solubility percentage of the each extract (freeze dried, oven dried and liquid sample), 1% (w/w) each of extract suspension were prepared in distilled water, and 30 mL of these suspensions were heated in the water bath at 30, 60, 70, and 90 °C for 30 min. During this time, the mixtures were continuously stirred. The tubes were stirred further for 2 h at 25 °C by a roller mixer. The samples were centrifuged at 800×g for 15 min and 10 mL of the supernatant dried in an oven at 105°C overnight until a constant weight was achieved. Finally, the solubility percentage was calculated according to the following equation (Sciariniet al., 2009):

$$\text{Solubility} = \frac{\text{Final weight} - \text{initial weight} \times 30}{10} \times 100$$

(iv)

2.3.5 Swelling index

One gram each of the extract(freeze dried, oven dried and liquid sample) were placed into a three 25mL glass Stoppard measuring cylinder. 25ml of water was added into the cylinderscontaining the extract and mixtures were shook thoroughly at interval of every 10min for one hour. The samples were allowed to stand for three hours at room temperature and volumes occupied by extract were measured. The mean value was calculated related to one gram of each extract (Uzmaet *al.*, 2013).

3.0 RESULT AND DISCUSSION

Table 1 shows the effect of soaking time on yield of *Okoho* mucilage. There was a steady increase in yield of the mucilage with increase in soaking time.

Table 1: Effect of Soaking Time on Yield of ‘Okoho’ Mucilage

Time (hours)	Weight of Okoho (Kg)	Volume of water (litres)	Yield (mL)
24	1	2	700
48	1	2	800
72	1	2	1000

Table 2 shows that all the assessed functional properties of the ‘Okoho’ mucilage samples differed significantly ($P < 0.05$) from one another. Comparing the different drying treatments, oven drying method had the highest value obtained for bulk density (0.88). High bulk density is desirable for reducing shipping and packaging costs as it implied that lesser packaging material would be required, as bulk density gives an indication of the relative volume of packaging material required (Dairy Products Technology Center, 2001). The results obtained in this research resembled a mirror image of the study conducted by Asif-Ul-Alamet *al.*, (2014), whereby bulk density of the hot-air oven dried banana flour was significantly higher than that of the freeze dried. This might be attributed to the higher porosity of the freeze dried extract.

The water absorption capacity (WAC) indicates the mass of the water uptake per unit mass of dried powder. Comparing hot-air oven drying to freeze drying method, WAC of oven-dried (22.12%) was significantly higher ($P < 0.05$) than that of freeze dried (20.65%). Results from determining WAC of flour samples dried by using hot-air oven dryer at temperatures of 40 and 60°C indicated that an increase in air dryer temperature, the WAC correspondingly increased. The same observation has been reported by (Rawaland Masih, 2014), whereby the WAC of the apple pomace powder increases when the tray dryer

temperature increased from 60 to 80°C. This was attributed to the increase in drying temperature and hydrophilic tendency of the starch increased alongside. Products with high WAC find useful applications as functional ingredients in bakery products as this could prevent staling by reducing moisture loss (Obatolu *et al.*, 2007). WAC is also important in the development of ready-to-eat foods and a high absorption capacity may assure product cohesiveness as reported by (Houson and Ayenor, 2002).

Comparing the different drying treatments, the freeze drying method had the higher value obtained for the oil absorption capacity (OAC) (2.85), while the lowest value was corresponded with the wet sample (0.63). The results obtained in this study are similar with the study by Sogiet *al.* (2013), whereby it is reported that the freeze dried mango kernel powder had the highest OAC values whereas the hot-air oven drying dried had lower values. The disparities observed could be attributed to the method used. Foaming capacity was significantly higher in wet sample. The fat content of the sample in its raw state must have played a significant role in this. The foaming properties are particularly important in the stability of ice cream and in bread production (Wilcox, 2006).

The swelling index of oven dried sample was lower than freeze dried sample. This might be due to the heat that is involved in oven drying, which contributed to the lower structure rigidity that collapsed the porous structure. As a consequence, the sample could not retain more water.

Table 2: Effect of Different Drying Methods on the Functional Properties of ‘Okoho’ Mucilage

Parameters	Samples		
	Freeze Dried	Oven Dried	Liquid Mucilage
Water Absorption Capacity	20.65 ^c ±0.02	22.12 ^b ±0.99	3.04 ^b ±0.06
Oil Capacity	2.85 ^b ±0.05	2.60 ^a ±0.40	0.63 ^a ±0.04
Bulk Density	0.78 ^a ±0.00	0.88 ^d ±0.01	#VALUE!
Foaming Capacity	68.15 ^c ±0.04	60.87 ^d ±0.05	75.09 ^b ±0.09
Solubility	47.84 ^b ±0.06	45.93 ^c ±0.05	16.27 ^a ±0.39
Swelling Index	62.00 ^a ±0.00	68.52 ^b ±0.04	58.61 ^c ±0.39

4.0 CONCLUSION

The results shows that the drying methods used impacted greatly on the inherent functional properties of the *Okoho* mucilage, which translates into the useful application of the dried extract in food systems such as syrup, clarifications, stabilizing and thickening agents.

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EFFECT OF PALM OLEIN ADDITION ON THE PHYSICOCHEMICAL PROPERTIES OF BAOBAB OIL DURING DEEP FAT FRYING

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Abstract

This paper presents an investigation on the effect of palm olein (PO) addition on the quality characteristics of Baobab oil (BO) during frying of potato pieces. The blends were prepared in the volume ratios of 90:10% (BO: PO, BOP1), 70:30% (BOP2), 50:50% (BOP3) and 30:70% (BOP4). Results showed that blending of BO with PO significantly improved the properties and quality of BO as shown in the refractive index of frying BO samples and its blends increased insignificantly ($P < 0.05$) as the number of frying performed by the oils increased, while the viscosity, free fatty acid content and peroxide value of the controlled oils and their blends all increased significantly at $P < 0.05$, whereas iodine value, tocopherol, tocotrienol, total vitamin E content and beta carotene content decreased significantly ($P < 0.05$) as frying progressed. Blend BOP3 and BOP4 showed better frying performance compared to BOP1 and BOP2. However, higher amounts of free fatty acids were both detected in the blends compared to pure BO at the end of frying. It appears that proper blending of highly unsaturated BO with PO can result in oil blends that could meet nutritional needs with improved stability for deep fat frying.

Keywords: Baobab oil, palm olein, deep fat, frying, blending

Introduction;

Vegetable oils and fats are essential nutrients of the human diet, they play a vital role in providing energy, mechanical and temperature protection of organs and the body. They are important raw materials which are utilized in the food industries. Recently, consumers are concerned about the quality of the edible oils used in frying operations and consumption. The quality, stability and nutritional characteristics are the key factors considered for use of edible oils in the food industries (Olagunju *et al.*, 2022). The quality and stability of frying fats are therefore of concern to food technologists, nutritionists, and consumers. Deep-fat frying is one of the most important, old method and popular procedures for food preparation. It is a rapid method and develops desirable flavours and texture to the food (Abbas Ali *et al.*, 2014). However, using frying oils repeatedly can lead to the production of undesirable constituents that not only compromise food quality but also can promote the formation of compounds with adverse nutritional implications and potential hazards to human health (Swinburn *et al.*, 2019). Baobab (*Adansonia digitata* L.) is an iconic tree with multipurpose use, belonging to the family of Bombacaceae which is a sub family of the Malvaceae (Diop *et al.*, 2006). The oils extracted from the baobab seeds (BO) have high proportions of unsaturated fatty acids of around 73.11% (linoleic and oleic acid, 39.42% and 26.07%), while 26.89% is saturated (Zahra'u, 2014). However, baobab oil is adjudged to be associated with low oxidative stability

and rancidity during frying owing to the high contents of polyunsaturated fatty acids present. These oxidative changes result in repugnant flavours, destruction of valuable nutrients and more likely generation of toxic compounds leading to economic loss to producers and consumers (Thorat *et al.*, 2012). Blending of vegetable oils have been considered to modify the physicochemical properties of oil meanwhile, the chemical composition is unaltered (Chu and Kung, 1998). This process is also recognized as a dynamic technique to achieve oils with optimum stability and fatty acid composition (Roiaini *et al.*, 2015). It is important to consider blending a less stable oil with one that has superior physicochemical properties; bearing this in mind guided the oil types and combination used in the current study. Palm olein (PO) is one of the unique oil that is available in large amounts to a comparatively low price, while the availability of high oleic oils is limited at the moment, resulting in higher price for the oil (Abbas Ali *et al.*, 2014). Palm olein is being used increasingly in frying operations, and because of its inherent excellent frying properties. The PO has been used to improve the frying quality and stability of other vegetable oils when it is blended with them (Abbas Ali *et al.*, 2014). Therefore, this research was performed to study the effects of PO addition on the physicochemical properties of BO during frying. The study is important as blended oils are rarely seen in the Nigerian markets.

Materials and methods

Frying test was performed for BO and its blends with PO. Several batches of sliced Irish potato (50 g) were fried in a 500 ml of oil at 185 ± 5 °C (using a thermometer to maintain the oil temperature) at intervals of 20 min up to 5 h per day for a total of 3 days. The oil samples were collected and stored at -16 °C for analyses each morning before replenishment. Physicochemical properties of the oil; Refractive index (RI) was measured according to method (Cc 7-25), Peroxide Value (Pv) method (Cd 8-53), Free Fatty Acid (FFA) method (Ca 5a-40), Iodine Value (IV) method (Cd 1-25/93) and the vitamin E and beta carotene contents were determined according to Official Method Ce 8-89 (AOCS, 1987) Official. Viscosity of the oils was measured using a Brookfield DV-II+ viscometer (Brookfield Engineering Laboratories Inc., Middleboro, USA).

Results and Discussion

As shown in Table 1, RI values of frying BO samples were increased insignificantly ($P < 0.05$) as the number of frying performed by the oils increased. These results could not be explained by the differences in fatty acids composition where BO contained higher amount of PUFA compared to its blends. On the other hand, the RI values for the blends BOP3 (1.4569, 1.4562, 1.4572, and 1.4577) and BOP4 (1.4539, 1.4542, 1.4548 and 1.4605) at corresponding frying days were significantly lower ($P < 0.05$) compared to pure BO (1.4690, 1.4695, 1.4718 and 1.4727) (Table 1). A similar trend was reported by Abbas Ali *et al.*, 2014 who heated canola oil blended with palm olein. The RI increases with an increase in polymerization, saturation of carbon-carbon double bonds and moisture in food. More so, the results of the modified baobab oils were within the range (1.466–1.470) established by

Codex (2015). It is well known that the PV is a measure of the content of hydroperoxides formed in fats and oils through oxidation processes. Hydroperoxides are the primary products of lipid oxidation; hence, determination of PV is used as oxidative index for the early stages of lipid oxidation in frying applications. PV of BO samples did not exceed the 10 meq/kg CODEX-STAN 210–1999, Turkish Codex Standards. However, blended oils had lower PV values (2.09 to 6.39 meq O₂/kg) as shown in Table 1.0. FFA formed due to oxidative degradation served as an indicator to measure rancidity of the oils. The higher the FFA values, the lower the possibility of the oils to be used for cooking purpose. Highest FFA value was recorded in day 3 fried oil of BO (7.82%), after blending BO with PO, the FFA value decreased significantly (4.30%) in BOP4 3rd day of frying. Iodine value (IV) measures the degree of unsaturation in a vegetable oil. Iodine value increases with increasing level of unsaturation. The initial IV for BO was 88.30 g which was higher compared to the IV values of BOP3 and BOP4. A similar outcome of stabilizing sunflower oil with sesame extract has been reported by Hussain *et al.* (2018). The viscosity of frying oils increased significantly ($P < 0.05$) with frying days (Table 1). The present results clearly revealed the higher deteriorative effect of BO compared to the blends. The content of beta carotene (Table 1) and tocopherol was higher in BO compared to PO and the blends, while that of tocotrienol was found to be high in PO (Figure 1). After subjecting all the oils to high temperature, the content of all antioxidants drop down from the initially meaning most of the vitamin E content disappeared after subjecting the oils to high heating.

Conclusion

Present study showed that blending of oil proved to be an effective means of stabilizing baobab oil and modifying its fatty acid composition. In this study, most of the chemical and physical degradation indicators suggested that the degradation was fastest in BO as compared to its blends with PO. Overall, based on the results reported herein, it can be concluded that addition of PO to BO slowed down the thermooxidative degradation rate of BO. BOP3 showed better performance compared to BOP1, BOP2 and BOP3. Therefore, further research is needed to find additional factors that are responsible to enhance the stability and nutritional value of Baobab seed oil.

Table 1.0 Physicochemical properties and Beta carotene content of Baobab seed oil after subjecting the oil to deep fat frying

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Table 1.0 Physicochemical properties and Beta carotene content of Baobab seed oil after subjecting the oil to deep fat frying

	Day	Palm Olein (PO)	Baobab (BO)	Palm Olein: Baobab Oil (%)			
				90:10 (BOP1)	70:30 (BOP2)	50:50 (BOP3)	30:70 (BOP4)
Physicochemical properties of the oils							
Refractive Index (25°C)	0	1.4528 ± 0.05 ^{2A}	1.4690 ± 0.04 ^{Ca}	1.4642 ± 0.51 ^{cA}	1.4589 ± 0.20 ^{bA}	1.4569 ± 0.24 ^{Ba}	1.4539 ± 0.28 ^{bA}
	1	1.4544 ± 0.05 ^{2A}	1.4695 ± 0.08 ^{Cab}	1.4651 ± 0.04 ^{cAB}	1.4592 ± 0.12 ^{bA}	1.4562 ± 0.12 ^{Ba}	1.4542 ± 0.22 ^{bA}
	2	1.4559 ± 0.04 ^{2AB}	1.4718 ± 0.05 ^{Cabc}	1.4678 ± 0.08 ^{cAB}	1.4602 ± 0.21 ^{bB}	1.4572 ± 0.31 ^{Bb}	1.4548 ± 0.21 ^{bB}
	3	1.4607 ± 0.03 ^{2AB}	1.4727 ± 0.04 ^{Cbc}	1.4696 ± 0.31 ^{BC}	1.4615 ± 0.31 ^{bBC}	1.4577 ± 0.33 ^{Bbc}	1.4605 ± 0.11 ^{bBC}
Viscosity (cP)	0	33.25 ± 0.04 ^{dA}	29.80 ± 0.16 ^{Aa}	30.08 ± 0.18 ^{2A}	31.35 ± 0.12 ^{cA}	31.99 ± 0.04 ^{Ba}	32.45 ± 0.01 ^{2A}
	1	34.35 ± 0.04 ^{2B}	35.22 ± 0.08 ^{Bb}	31.62 ± 0.28 ^{bB}	35.55 ± 0.20 ^{cB}	34.95 ± 0.08 ^{Db}	34.78 ± 0.02 ^{2B}
	2	36.10 ± 0.08 ^{2C}	42.39 ± 0.24 ^{Cc}	41.29 ± 0.25 ^{cC}	40.70 ± 0.08 ^{BC}	38.75 ± 0.04 ^{Bc}	36.97 ± 0.02 ^{bC}
	3	36.25 ± 0.12 ^{2D}	45.75 ± 0.39 ^{Cd}	44.35 ± 0.33 ^{cD}	43.83 ± 0.53 ^{bD}	39.85 ± 0.04 ^{Bd}	36.44 ± 0.03 ^{bD}
Peroxide Value (mEq/kg of oil)	0	1.26 ± 0.06 ^{2A}	3.20 ± 0.06 ^{Aa}	2.72 ± 0.02 ^{2A}	2.10 ± 0.03 ^{2A}	1.96 ± 0.24 ^{Ba}	1.4539 ± 0.28 ^{bA}
	1	2.15 ± 0.04 ^{2B}	5.23 ± 0.05 ^{Db}	3.88 ± 0.05 ^{cB}	2.87 ± 0.02 ^{bB}	1.72 ± 0.12 ^{Ba}	1.4542 ± 0.22 ^{bA}
	2	3.27 ± 0.17 ^{2C}	6.90 ± 0.07 ^{Bc}	5.59 ± 0.05 ^{cC}	3.90 ± 0.14 ^{2C}	1.83 ± 0.31 ^{Bb}	1.4548 ± 0.21 ^{bB}
	3	5.12 ± 0.13 ^{2D}	8.89 ± 0.14 ^{De}	6.88 ± 0.04 ^{cD}	5.10 ± 0.07 ^{bD}	2.09 ± 0.33 ^{Bbc}	1.4605 ± 0.11 ^{bBC}
FFA (%)	0	0.12 ± 0.01 ^{2A}	6.87 ± 0.00 ^{Aa}	5.11 ± 0.01 ^{2A}	4.13 ± 0.02 ^{2A}	4.01 ± 0.01 ^{2A}	3.45 ± 0.01 ^{2A}
	1	0.26 ± 0.02 ^{2B}	7.19 ± 0.01 ^{Ab}	5.78 ± 0.02 ^{2B}	4.28 ± 0.03 ^{2B}	4.18 ± 0.02 ^{2B}	3.78 ± 0.02 ^{2B}
	2	0.42 ± 0.02 ^{2C}	7.54 ± 0.04 ^{Ac}	5.97 ± 0.02 ^{2C}	4.79 ± 0.02 ^{bC}	4.37 ± 0.02 ^{2C}	3.97 ± 0.02 ^{bC}
	3	0.57 ± 0.04 ^{2D}	7.82 ± 0.02 ^{Ad}	6.39 ± 0.03 ^{2D}	5.14 ± 0.04 ^{2D}	4.59 ± 0.03 ^{2D}	4.30 ± 0.03 ^{2D}
I ₂ Value	0	57.32 ± 0.95 ^{2C}	88.30 ± 0.71 ^{De}	85.52 ± 0.74 ^{cC}	76.31 ± 0.62 ^{bE}	69.31 ± 0.62 ^{Be}	65.30 ± 0.62 ^{bE}
	1	57.98 ± 0.71 ^{2C}	88.08 ± 0.64 ^{De}	85.46 ± 0.42 ^{cB}	76.46 ± 0.41 ^{bE}	69.46 ± 0.41 ^{Be}	65.16 ± 0.41 ^{bE}
	2	55.89 ± 0.66 ^{2B}	87.45 ± 0.48 ^{De}	85.33 ± 0.44 ^{cB}	76.09 ± 0.29 ^{bD}	69.23 ± 0.29 ^{Bd}	65.07 ± 0.29 ^{bD}
	3	54.56 ± 0.28 ^{2AB}	87.23 ± 0.95 ^{De}	85.14 ± 1.01 ^{cA}	75.23 ± 0.50 ^{bC}	69.09 ± 0.50 ^{Bc}	65.02 ± 0.50 ^{bC}
Beta carotene (ppm)	0	118.73 ± 0.04 ^{dA}	144.80 ± 0.16 ^{Aa}	134.08 ± 0.18 ^{2A}	127.35 ± 0.12 ^{cA}	120.99 ± 0.04 ^{Ba}	119.45 ± 0.01 ^{2A}
	1	90.35 ± 0.04 ^{2B}	128.22 ± 0.08 ^{Bb}	112.62 ± 0.28 ^{bB}	108.55 ± 0.20 ^{cB}	105.95 ± 0.08 ^{Db}	102.78 ± 0.02 ^{2B}
	2	87.10 ± 0.08 ^{2C}	90.39 ± 0.24 ^{Cc}	89.29 ± 0.25 ^{cC}	90.70 ± 0.08 ^{BC}	88.75 ± 0.04 ^{Bc}	89.97 ± 0.02 ^{bC}
	3	72.25 ± 0.12 ^{2D}	86.75 ± 0.39 ^{Cd}	84.35 ± 0.33 ^{cD}	83.83 ± 0.53 ^{bD}	82.85 ± 0.04 ^{Bd}	75.44 ± 0.03 ^{bD}

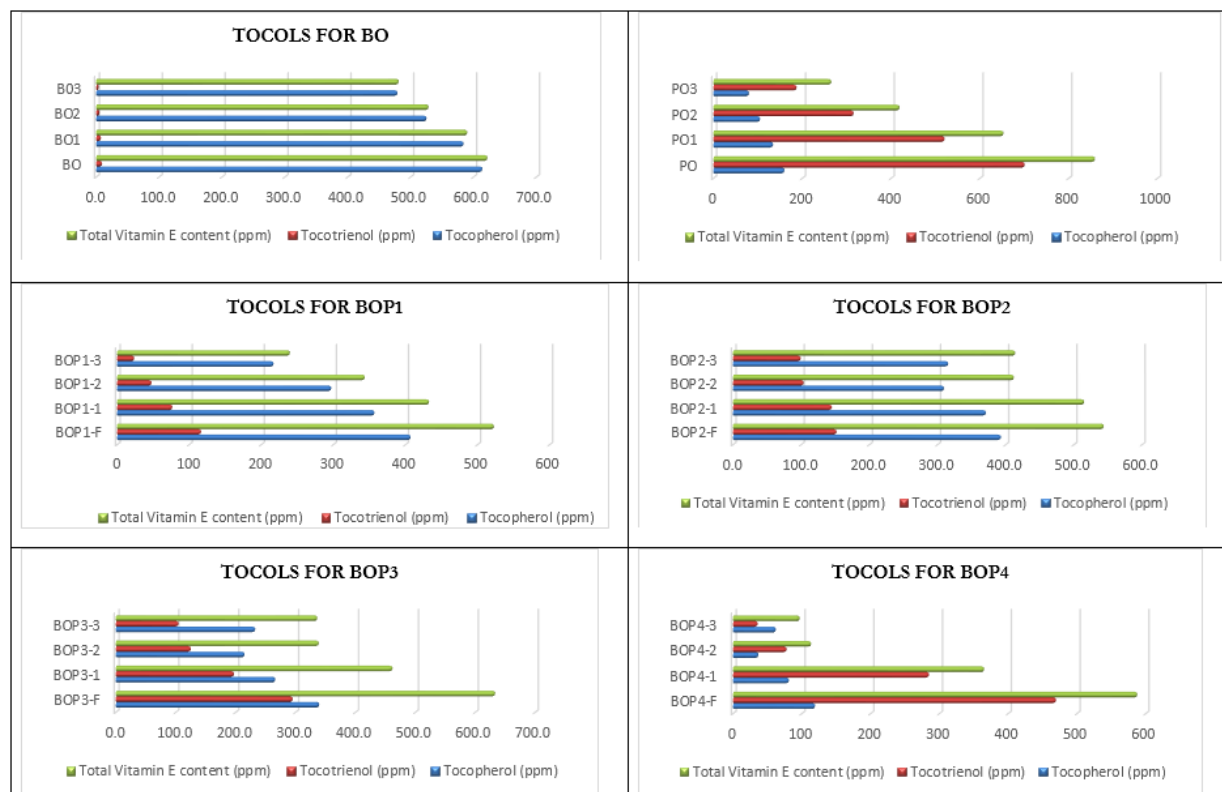


Figure1 Vitamin E content for BO, PO and the blends

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EFFECT OF DIFFERENT DRYING METHODS ON THE MINERAL COMPOSITION OF *JUSTICIA SECUNDA* LEAVES

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Abstract

The study aimed at evaluating effects of different drying methods on mineral composition of *Justicia secunda* leaves powder dried by cabinet dryer at 70°C for 12 h, solar dryer for 24 h and at room temperature of about 28 to 32°C for 2 weeks. Minerals (sodium, potassium, calcium, magnesium, iron, copper, manganese, zinc, phosphorus and selenium) were determined in the dried leaves using atomic absorption spectrophotometry. The results showed drying increased the concentration of the minerals with cabinet dried samples having highest concentration of many of these minerals (Na, K, Ca and Fe) while solar drying had highest concentration of Zn, P, and Mn. The values obtained ranged from 9.89 – 397.09 ppm, 646.27 – 1493.88 ppm, 2745.88 – 5490.96 ppm, 609.67 – 1263.44 ppm, 76.71 – 290.21 ppm, 0.34 – 1.88 ppm, 1.99 – 12.76 ppm, 0.81 – 10.4 ppm, 81.57 – 476.05 ppm and 0.001 – 0.016 ppm for Na, K, Ca, Mg, Fe, Cu, Mn, Zn, P and Se respectively with significant difference ($p < 0.05$). The study showed that drying of *J. secunda* leaves without diminishing the mineral composition was best at 70°C for 12 h, followed by solar drying for 24 h.

Keywords: *Justicia secunda*, leaves, cabinet drying, solar drying and minerals

Introduction

The highest prevalence of undernourishment is in Africa with an estimate of 20% in 2016 (FAO, 2017). In order to fight hunger and diseases therefore, many organizations and governments have encouraged the use of vegetal sources of minerals and proteins (FAO, 2017). The contribution of some leafy vegetables in the reduction of malnutrition among rural population has been documented (Ishiekwe, 2020). Vegetables are excellent sources of minerals that contribute to the recommended dietary allowances of the essential nutrients required for normal metabolic activities of the body tissues.

Justicia secunda M. Vahl (*Acanthaceae*) is a plant used in traditional medicine in many countries in sub-saharan Africa especially in West-Africa. It is used in the treatment of diabetes, depression, epilepsy, mental disorder wound healing, anemia and abdominal pain and or gastro enteritis (Kitadi *et al.*, 2019). The leaves of *J. secunda* appears to be a very important source of iron, with a high iron contents of 240 mg/g thus justifying its use as anti-anemic

agent.

Vegetables are generally perishable products due to their high moisture content which ranges between 60.0 - 98.8 %. *J.secunda* like other leafy vegetables is also perishable, and suffers scarcity and lack of accessibility to all. Processing the leaves into shelf stable product available all year round would ensure availability and wider usage such as an infusion or as a food supplement incorporated into local dishes. Previous studies have documented drying of leaves of *J.secunda* but literature is dearth on the comparative drying methods that would ensure minimal reduction in quality. Hence this study evaluated the effects of different drying methods on the mineral composition of *J.secunda*

Methodology

Preparation of *Justiciasecunda* Powder

Matured fresh leaves of *J.secunda* were obtained from Fish Farm estate, Odonguyan in Ikorodu, Lagos, Nigeria. The leaves were sorted, cleaned and foreign materials were carefully removed. Two hundred gram was weighed, washed ,drained and dried using the three different methods; Cabinet drying at 70 °C for 12 h (ABC), Solar drying for 24 h (GHI) while sample MNO was dried at room (ambient) temperature of between 28 °C and 32 °C for 2 weeks (14 days). Each batch of the dried leaves was blended using an electrical Qasa blender Model QBL_2088 (Japan) and sieved using 350µm mesh size.

Mineral analyses

Two gram of each dried sample was weighed into a porcelain crucible and ashed at 550 °C for 3 h. The crucible was allowed to cool and the ash obtained was dissolved in 100ml of NH₃Cl. It was stored in a plastic bottle with a plastic cap.

Spectrophotometric Determination

Corresponding lamp was placed with corresponding mineral and the wavelength specific for each metal determination was set (Ssodium Na- 589.00nm, potassium K -766.50nm, calcium Ca-422.8nm, magnesium Mg- 285.20nm,iron Fe-248.30nm, copper Cu -324.80nm, manganese Mn -279.5nm, zinc Zn -213.90nm and lead Pb 217.00nm). Atomic absorption spectrophotometer's siphoning hose was placed into the digested sample after running the standards for each mineral. The concentration of each mineral element in the solution was displayed on the screen of the AAS machine.

Results and Discussion

The mineral composition of *Justicia secunda* powder dried with different drying methods is shown in Table 1. Drying increased significantly ($p < 0.05$) the concentration of many of the minerals present in the leaves. The concentration of Na, K, Ca, Mg, and P ranged from 90.89-397.09 ppm, 646.27-1493.88 ppm, 2745.88-5490.69 ppm, 609.67-1263.44 ppm, and 81.57-476.04 ppm respectively while mineral elements such as Fe, Mn, Cu and Zn ranged from 76.71-290.21 ppm, 1.98-12.76 ppm and 0.34-1.88 ppm, 0.81– 10.40 ppm respectively. This could be attributed to concentration effect as drying evaporates moisture present in the leaves. Further, according to Nielsen (2010), most minerals have limited volatility at high temperatures of up to 550 - 600°C, hence they are retained as water evaporates from the

system. The table shows Cabinet dried leaves had the highest concentration of many of these minerals while leaves dried with solar dryer (GHI) had highest concentration of Mg, Mn, Zn and P. However, the concentration of Fe in both cabinet dried and solar dried leaves did not differ significantly ($p>0.05$) while methods of drying had no significant effect ($p>0.05$) on the Cu content. This observation is in tandem with the study of Karimian-Khosroshahi et al. (2016) who reported that different mineral elements behave differently to different heating methods. Generally, the fresh leaves had the lowest concentration of these minerals. Selenium content of *J. secunda* powder was relatively very low and ranged from 0.01 to 0.02 ppm with significant difference ($p<0.05$) existing among the samples. Cobalt, cadmium and lead (data not shown) were however not detected.

Drying of the leaves in the cabinet dryer provided a relatively faster method of drying (12 hr) compared to others which due to its design, allows evaporated moisture to be quickly removed. In contrast, air drying at room temperature for two weeks is seasonal dependent and might support microbial growth e.g fungal growth before the completion of the drying process. Liman et al. (2014) opined that different elements behave differently under different drying conditions and this may also vary with the type of vegetables. The increase in mineral content with drying as found in this study contradicts the report of Ogunlakin et al. (2020) who reported a considerable reduction in the mineral composition of waterleaf (*Talinum triangulare*) with various drying methods. This difference might be due to the nature of the leaf and nature in which the water in the leaf exist.

These minerals have been indicated in many metabolic functions. According to Abbaspour *et al.* (2014), iron is essential for hemoglobin formation, oxygen transport, energy metabolism, immune and brain function and its involvement in oxidation reduction reactions. Zinc stimulates the activity of over a hundred enzymes, it is needed in the biosynthesis of DNA and wound healing, Sodium is essential for the absorption of glucose in the kidney and intestine and the transport of other nutrients across membranes while K influence muscle activity; especially cardiac muscle (Vishwanath, 2012). Calcium (Ca) plays active roles in the biological functions of many tissues, The concentration of Ca in this study is higher than values (204.26 to 305.51mg/100g) reported by Chinma and Igyor (2007) for selected green leafy vegetables in SouthEast, Nigeria.

Table1: Mineral Composition of *Justicia Secunda* Powder obtained using Different Drying Method s(ppm)

*Mean $\pm$ standard deviation with same superscripts along the column are not significantly different at ($p>0.05$). ABC = Leaves Dried with Cabinet Dryer, GHI= Leaves Dried with Solar Dryer, MNO= Leaves Dried with Room Temperature, STU=Fresh Leaves

ample	Sodium	Potassium	Calcium	Magnesium	Iron	Copper	Manganese	Zinc	Phosphorus
ABC	397.09 $\pm$ 0.72 ^d	1493.88 $\pm$ 2.63 ^d	5490.69 $\pm$ 2.31 ^d	1257.53 $\pm$ 0.19 ^{bc}	290.21 $\pm$ 0.30 ^c	1.84 $\pm$ 0.04 ^b	10.05 $\pm$ 0.09 ^b	7.29 $\pm$ 0.04 ^b	371.51 $\pm$ 0.93 ^b
GHI	333.99 $\pm$ 0.40 ^b	1389.81 $\pm$ 1.74 ^c	5408.66 $\pm$ 3.67 ^c	1263.44 $\pm$ 5.20 ^c	288.96 $\pm$ 1.90 ^c	1.87 $\pm$ 0.05 ^b	12.76 $\pm$ 0.26 ^d	10.40 $\pm$ 0.38 ^d	476.04 $\pm$ 3.12 ^d
MNO	386.87 $\pm$ 0.34 ^c	1363.62 $\pm$ 0.96 ^b	5387.30 $\pm$ 2.08 ^b	1253.51 $\pm$ 2.65 ^b	279.78 $\pm$ 1.45 ^b	1.88 $\pm$ 0.03 ^b	11.06 $\pm$ 0.13 ^c	8.42 $\pm$ 0.28 ^c	392.95 $\pm$ 2.81 ^c
STU	90.89 $\pm$ 0.45 ^a	646.27 $\pm$ 2.67 ^a	2745.88 $\pm$ 5.88 ^a	609.67 $\pm$ 1.10 ^a	76.71 $\pm$ 0.11 ^a	0.34 $\pm$ 0.00 ^a	1.98 $\pm$ 0.08 ^a	0.81 $\pm$ 0.03 ^a	81.57 $\pm$ 0.83 ^a

Magnesium is highly needed for the activation of various enzymes ,important for bone formation and carbohydrates metabolism while Manganese is required for the synthesis of mucopolysaccharides. Copper on the other hand is necessary for effective utilization of iron. The Fe content was higher than that reported for *Hibiscus sabdariffa* leaf (0.42ppm) but slightly lower than *Hibiscus asper* (0.67ppm) leaf (Arogbodo and Ajayi, 2020). The level of iron content might justify its use as haemanitics, hence the consumption of the leaves of *J. secunda* will go a long way in solving anaemia related health challenge. It will also help in meeting the daily dietary need of iron by individuals which varies with age, sex and physiological state. The relative absence (Not detected)of Pb, Cd, and Co in this study is a good indication as the consumers of the leaf or its product(s) will not be exposed to the adverse effects of these heavy metals.

Conclusion

The study investigated the effect of varying drying methods on the minerals composition of *J.secunda*. Drying of the leaves of *J.secunda* not only makes the leaves available all year round but also ensure accessibility to many while not diminishing the relative abundance of the various minerals present. Cabinet drying method provided higher concentration of majority of the minerals investigated followed by solar drying. The result of the elemental constituents of *J. secunda* showed the plant to be an abundant source of the evaluated mineral elements except cobalt, lead and chromium. Commercial production of dried leaves powder of *J.secunda* is thus possible by cabinet drying (70°C for 12 hr) and solar drying with increased concentration of mineral nutrients. The dried leaves powder can be incorporated into foods or used as an infusion to solve many nutritional challenges.

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ASSESSMENT OF MICROBIOLOGICAL SAFETY OF LOCALLY MANUFACTURED DRINKS (*KUNUN AND ZOBO*) SOLD IN TWO TERTIARY INSTITUTIONS IN OWERRI

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Abstract

This work assessed the micro-biological safety of locally manufactured drinks (*kunun and zobo*) sold in two tertiary institutions in Owerri. Three *kunu-zaki* and three *zobo* samples were collected and analyzed using standard methods of microbiological analysis (biochemical tests) -catalase, coagulase, oxidase, sugar fermentation/oxidation, hydrogen sulphide production (H₂S), urease, imvic, indole and citrate utilization. Ninety-eight percent (98%) of the *kunu-zaki* and ninety-five percent (95%) of the *zobo* drinks showed growth presumed to be pathogenic bacteria. The occurrence of *Staphylococci* spp. is higher in both *kunun-zaki* and *zobo* drink samples (64.0% and 48.0%, respectively) and followed by *Streptococci* spp. (16.7% and 20.0%, respectively). This was observed in the case of *Bacillus* spp. (8.9% and 4.0%, respectively), *Escherichia coli* (6.0% and 3.0%, respectively) and yeast (2.7% and 0.0%, respectively). However, *zobo* drinks recorded higher occurrence of *Salmonella* sp. than *kunun-zaki*. No yeast was isolated from all the *zobo* drink samples examined. The presence of these bacteria is of public health importance since most of them are implicated with food-borne gastroenteritis in humans. The contamination was mainly post-processing due to poor personal and environmental hygiene of processors/vendors and place of manufacture/sale, which led to faecal contamination of the drink during handling (packaging and sales). Proper hygienic and sanitary measures are recommended during processing and sale to prevent the contamination of these local drinks.

Keyword: Assessment, *kunun*, *zobo*, microbiological safety.

Introduction

In countries like Nigeria, people depend mostly on indigenous technology for food preparations especially foods of plant origin. Some of the food products that originate from plant include beverage such as *kunun and zobo* drinks (Odunfa, 2008). *Kunun* is a non-alcoholic, indigenous and traditional fermented beverage widely consumed in the Northern parts of Nigeria. It is widely consumed for its taste, nutritional value and used during festivities, weddings, schools and in naming ceremonies. The drink is taken as an appetizer and has thirst-quenching properties.

Zobo drink is a traditional, non-alcoholic beverage which is consumed in most parts of Nigeria, mostly in northern parts of Nigeria (Osuntogun, 2004). The economic and religious

situation in Nigeria has made the *zobo* drink gain wide acceptance on different occasions. It is used as a refreshment, entertainment in parties or as an appetizer before the main dish is served.

Food borne intoxication is common in man (USFDA, 2008), and local beverages and non-alcoholic drinks may be common sources of infection. The consumption of these local drinks is of public health significance. Hence, local drinks may serve as vehicles for food-borne diseases or pathogens such as *Staphylococcus*, *Salmonellosis*, *Brucellosis*, *Tuberculosis*, *Shigellosis*, *Listeriosis*, *Escherichia coli* infections, etc.

Materials and Methods

Locally manufactured drink samples used in this study were procured from vendors of *kunun* and *zobo* in the two purposively selected tertiary institutions in Owerri. By convenience sampling technique, a total of 6 samples comprising two each of local drinks (*kunun* and *zobo*), was obtained from 3 major food vending sites in the institutions. Samples were collected when freshly prepared. The samples were kept in the containers in which they were bottled, and was taken in cold packs, under aseptic condition, to the laboratory for microbiological analyses within one hour of collection.

Biochemical tests -catalase, coagulase, oxidase, sugar fermentation/oxidation, hydrogen sulphide production (H₂S), urease, imvic, indole and citrate utilization were done to isolate and identify micro-organisms in the drink samples.

Results and Discussion

Table 1: Biochemical and sugar fermentation test of Bacterial Isolates for *Kunun* and *Zobo* Sample

Cat	Oxi	Coag	In	MR	VP	Cit	Ure	NO	H ₂ S	Suc	Lac	Mal	Man	Glu	Identity of Isolates
3															
+	-	-	-	+	-	+	+	-	-	-	-	-	-	-	<i>Micrococcus Luteus</i>
+	-	-	-	+	-	-	-	-	-	+	+	+	+	+	<i>Enterococcus faecalis</i>
+	-	-	-	-	+	-	-	-	-	-	-	-	+	+	<i>Bacillus subtilis</i>
+	-	-	-	-	+	-	-	-	-	-	-	-	+	+	<i>Bacillus cereus</i>
+	-	-	-	-	+	-	-	-	-	-	+	-	+	+	<i>Enterobacter sp</i>
+	-	-	-	-	+	+	-	-	-	+	+	-	+	+	<i>Klebsiella sp</i>
+	-	+	-	-	+	-	+	-	-	+	+	+	+	+	<i>Staphylococcus aureus</i>

Key: Catalase test(Cat), Oxidase test (Oxi), Coagulase test (Coag), Indole test (In), Methyl Red (MR) and Voges Prokauer (VP), Urease test (Ure), Citrates test (Cit), Glucose

(Glu), Sucrose (Suc), Lactose (Lac), Maltose (Mal), Xylose (XYL)

Result in Table 1 above represents the biochemical and carbohydrate fermentation of bacterial isolates in local drink samples from institutions A and B. The result revealed the different identities of isolates which include *Micrococcus luteus*, *Enterococcus faecalis*, *Bacillus subtilis*, *Bacillus cereus*, *Enterobacter sp.* *Klebsiella sp.* and *Staphylococcus aureus*. It strongly indicates that locally manufactured drinks could have been contaminated through poor handling by the food processors/vendors since *E-coli* and *Enterococcus faecalis* are indicative of faecal contamination in the samples (zobo and *kunun*) of institution A and B.

Table 2: The Pathogens in the identified micro-organisms

Location	Sample Code	Colony Types	Colonial Characteristics	Grams Morphology	Motility Test	Spore Formation	Most probable Identity
A	ZO1	ZOI _z	Smooth shiny golden yellow colonies	Gram positive cocci in chain	-	-	<i>Staphylococcus</i>
		ZO2 _y	Smooth shiny golden yellow colonies	Gram positive cocci in chains	+	+	<i>Staphylococcus Sp</i>
		ZO2 _z	Small smooth shiny cream colonies	Gram positive cocci in chains	-	-	<i>Enterococu sp</i>
B	ZO2	ZO2 _z	Small circular cream colonies on NA	Gram positive cocci in chains	+	+	<i>Enterococcus Sp</i>
		ZO2 _y	Smooth golden yellow colonies on NA	Gram positive predominantly in cluster, few in tetrads and pairs	-	-	<i>Staphylococcus Sp</i>

Key: ZO1 x yz = *Zobo* Sample with different colonies characteristic of bacteria; ZO2 xyzt = *Zobo* Sample with different colonies characteristic of bacteria.

Result in Table 2 above shows the pathogens in the identified micro organisms. Pathogens are disease-causing organisms; the identified pathogens were *Staphylococcus Sp* and *Enterococcus sp.* *Staphylococcus sp.* are pathogenic hence, they are harmful to human health; they can cause infection to human health (Taylor and Unakal,2022). *Enterococcus* species are pathogens that

can cause a variety of infections to human health.

Conclusion and Recommendation

The total mean count of bacterial isolates in the *kunun* and *zobo* was found to be 3.0×10^2 and 2.27×10^6 cfu/g. Ninety-eight percent (98%) of the *kunu-zaki* and ninety-five percent (95%) of the *zobo* drinks showed growth presumed to be pathogenic bacteria. The occurrence of *Staphylococci* spp. is higher in both *kunun-zaki* and *zobo* drink samples (64.0% and 48.0%, respectively) and followed by *Streptococci* spp. (16.7% and 20.0%, respectively). This was observed in the case of *Bacillus* spp. (8.9% and 4.0%, respectively), *Escherichia coli* (6.0% and 3.0%, respectively) and yeast (2.7% and 0.0%, respectively). However, *zobo* drinks recorded higher occurrence of *Salmonella* sp. than *kunun-zaki*. Microbiological guidelines for food (for ready to eat food in general and specific food items) show that *kunun* samples from both institutions A and B were unsatisfactory. Apparently, this signified that drinks are contaminated due to poor hygienic practices of vendors, which could cause food poisoning hence, this lowers the nutritional values of these drinks due to food borne disease and some gastro intestinal diseases that could result in human health (WHO, 2001). The circumstances surrounding the environment where the drinks are prepared matter. This is in line with (Barro, 2006) who reported the danger in foods especially food drinks and food contaminated with microbes; food producers do not take adequate hygienic precautions in food preparation, and consumers seem to eat with reckless abandon.

It is strongly recommended that tertiary institutions should assess the personal hygiene of the vendors before accepting them and their wares in the environment. Task force should also be set up to monitor the tested and approved vendors in the institutions.

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CHAPTER 6

FOOD MICROBIOLOGY AND BIOTECHNOLOGY

EVALUATION OF FUNGAL AND AFLATOXINS IN FRESH, DRIED AND CANNED MUSHROOM SAMPLES SOLD IN OSUN STATE, NIGERIA

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Abstract

Foodborne disease is a major menace to the public, and is often times assessed through microbiological evaluation of the concerned food produce. Consumption of mushrooms promotes good health, but is prone to microbial and aflatoxin contamination which could occur at any stage in the food chain such as; harvesting, processing and storage. Fresh mushrooms were purchased from two different farms in Ile-Ife, Osun-state while two commercial canned mushrooms were purchased from Shoprite. Some quantities of the fresh mushroom samples from the two farms were sun-dried for a period of two weeks prior to fungal and aflatoxin analysis. All samples were collected in sterile ziploc bags and transported to the laboratory. Fungal isolation and aflatoxin quantification were carried out on the samples using standard microbiological procedures and High Performance Liquid Chromatography (HPLC), and observed under ultraviolet ray at wavelength of 365nm. Various species of *Aspergillus* were isolated from the samples which includes; *Aspergillus flavus*, *Aspergillus candidus*, *Trichoderma spp.* and *Rhodotorula spp.* Thirty (30) % of the isolates were aflatoxigenic with canned mushroom having the highest aflatoxin concentration (3ng/kg). Public awareness on the dangers caused by consumption of contaminated mushroom which is pathogenic should be emphasized to avoid foodborne disease pandemic.

Keywords: Canned, Contamination, Foodborne disease, Mushrooms, Menace

Introduction

Mushrooms are fleshy and edible macro fungi that grow on a wide range of organic substrates. Edible mushrooms are highly nutritious foods usually eaten raw or cooked to garnish meals.

These mushrooms are either picked from the wild and typical examples of some species of edible mushrooms which are grown in Nigeria include: *Agaricus bisporus* (button mushroom), *Pleurotus ostreatus* (oyster mushroom) etc. (Chandra *et al.*, 2009). Mushrooms are enjoyed for their flavours and texture as they can impart flavour to food and still retain their texture during cooking. Cultivation of mushroom is becoming increasingly popular in Nigeria due to an increased awareness on the use of mushrooms. Mushrooms are usually eaten fresh but because of their high water content which makes them highly perishable, there is the need to preserve them. Sun drying is one of the most important processes used in preserving fruiting bodies of mushrooms, as this prolongs their shelf life. Drying removes water in mushroom so as to minimize biochemical and microbial activities (Kumeret *et al.*, 2011). Products derived from traditional sun drying usually exhibit poor quality due to unhygienic storage conditions. During drying, microorganisms may contaminate mushroom and secrete potentially toxic metabolites into them. The high humidity which exists during storage also predisposes the samples to invasion by microorganisms. The presence of these biological and chemical contaminants has varying effects on the health and productivity of humans (Shephard, 2008). Aflatoxin affects diverse agricultural products such as grains, pulses, oil seeds, and fruits from most developing countries in Africa (Bankole *et al.*, 2006). They are lethal if consumed causing liver, and kidney tissue damage while at low lethal exposure they cause potent human hepatocellular carcinogen and high level causing death. (Jyoti and Malik 2013). In the past decades, it has been observed that there is paucity of information on microorganisms associated with fresh and canned mushrooms. Therefore, it is imperative to determine the fungal contamination in mushrooms.

Materials and Methods

Fresh mushrooms were purchased from Ile-Ife, Osun state while canned mushrooms were purchased from Shoprite. Some quantities of the fresh mushroom samples were dried for a period of two weeks to (4-8 % moisture level) prior to microbial analysis. The fresh and canned mushroom samples were kept in sterile paper bags and then stored in a refrigerator; while the dried mushroom was stored in a Ziploc bag. The samples (fresh, dried and canned) were pounded. One (1)g of each of the grounded mushroom was poured into 9 ml of peptone water and 1 ml pipetted into a petri dish using pour plate method for the fungal analysis. Potato Dextrose Agar was the medium used and was prepared according to manufacturer's instructions and autoclaved for 15 min at 121°C. The fungi isolates were smeared on the microscopic slides and stained with Lacto-phenol cotton blue and allowed to dry. It was then viewed under the microscope with objective lens x40.

Preparation of Mushroom Sample And Quantification Of Aflatoxin

Mushroom samples were ground using a high speed Waring laboratory blender and 25 g sub-sample was weighed out from the bulk sample after thorough mixing. Aflatoxin extraction was

done using the modified method of Kimani (2012). Samples were extracted with 80% methanol at the ratio of 5 ml: 1g and 2% of sodium chloride. The mixture was shaken with the orbital shaker for 30 minutes and filtered using Whatman paper No. 1. The solution was extracted twice; first with 25 ml n-hexane and then 25 ml chloroform. The chloroform layer was collected and evaporated to dryness leaving the toxin extracts. The extracts were then dissolved with 1 ml of chloroform. Screening of the analytes was performed using a 1290 Series High Performance Liquid Chromatography (HPLC) System (Agilent, Waldbronn, Germany). consisting of two PU-1580 chromatographic pumps, an AS 1555 sampling system, a FP 1520 fluorescence detector (Jasco Corporation, Tokyo, Japan)



Figure 1.0: (a) Fresh mushroom (b) Dried mushroom

Results and Discussion

Fungal contamination of foodstuffs is an increasing food safety concern in sub-sahara Africa (Bankole *et al.*, 2006). The moisture content and water activity of foodstuffs are critical to the rate of colonization of such materials by molds. Based on the result obtained from the study, major isolates were *Aspergillus flavus*, and *Aspergillus candidus* and it was similar to the work of Frisvad and Samson (2004). The occurrence of *Aspergillus species* in dried mushroom samples is in line with the reports of Jonathan and Esho (2010). After three months of storage, highest aflatoxin level (3ng/kg) was detected in the canned mushroom even though at minimal concentration a little below permissible limit of 5ng/kg. Absence of Aflatoxigenic mould in the dried samples may be attributed to the fairly good storage condition after drying since the mushroom was stored for 3 months in sterile Ziploc bag in contrast to the canned ones. No aflatoxin was detected in fresh and dried mushroom samples this is in accordance with the study of (Ezekiel *et al.*, 2013). This may be due to water activity of the sample which was sufficient for mold growth but not aflatoxin production and mushroom samples may contain some natural chemicals which inhibit aflatoxins Schmidt-Heydt *et al.*, (2009).

Table 1.0: Morphological Characterization of Fungi Isolate

Samples		CC	TS	SS	SEP	SO
Canned Mushroom	Plate 1	Greenish-yellow	Conidia	Spherical	Septate	<i>Aspergillus flavus</i>
	Plate 2	White	Conidia	Spherical, globose and smooth	Septate	<i>Aspergillus candidus</i>
Fresh Mushroom	Plate 1	Pink	Blastoconidia	smooth, soft and mucoid	Non-Septate	<i>Rhodotorula spp</i>
	Plate 2	Greenish yellow	Conidia	Spherical	Septate	<i>Aspergillus flavus</i>
Dried Mushroom	Plate 1	Brown	Conidia	Spherical	Septate	<i>Aspergillus spp</i>
	Plate 2	Whitish	Conidia	Long, subglobulose	Septate	<i>Trichoderma spp</i>

Key:

CC= Colour of Colony; TS= Type of Spore; SEP= Septation; SS= Shape of Spores; SO= Suspected Organism

TABLE 2.0: Comparism between total aflatoxin quantification at the first and third month in ng/kg

SAMPLES	TOTAL AFLATOXIN AT FIRST MONTH (ng/kg)	TOTAL AFLATOXIN AT THIRD MONTH (ng/kg)
Canned Mushroom	0.00	3.00
Fresh Mushroom	0.00	1.00
Dried Mushroom	0.00	0.00

Conclusion

Relatively low incidence of aflatoxin in canned mushroom after three months of storage should be of public health concern because there is no threshold at which no harmful effect occurs.

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MICROBIAL QUALITY ASSESSMENT AND PROXIMATE COMPOSITION OF WINE PRODUCED FROM SELECTED GRAPES USING *Saccharomyces cerevisiae* ISOLATED FROM FERMENTED MILK

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ABSTRACT

This research aimed to produce wine from the fermentation of selected grapes using *Saccharomyces cerevisiae* isolated from fermented milk. The yeast was isolated using the pour plate technique and identified using cultural morphology, microscopic appearance, the carbohydrate utilization (sugar) test and ethanol tolerance test. Green and purple grapes were placed in different conical flask. Changes in temperature, pH, titratable acidity, volatile acidity, alcohol content, specific gravity (physicochemical parameters) were determined at intervals using standard methods. The yeast isolate had an ethanol tolerance of up to 14%. The physicochemical parameters were relatively stable throughout the wine production process. The temperature ranged from 27°C - 28°C. The pH rose after fermentation. The specific weight decreased in all produced wines. Results of the proximate composition of green and purple grape wines showed varied percentages. The microbial analysis showed that bacterial isolates were dominated by yeast isolates. The sensory evaluation showed that both green and purple grape wine had an overall acceptance. The shelf life results showed that purple grape wine got spoilt faster than green grape wines. This study has shown that locally isolated yeast strains and locally available grape fruits can be used to produce wines with good nutritional and microbiological quality.

Keywords: Yeast, fruits, wine, sensory evaluation, shelf life

INTRODUCTION

Wine is generally defined as the product of normal alcoholic fermentation of the juice of healthy ripe grapes. Grape wine is perhaps the most economically important alcoholic fruit juice (Kelebek et al., 2013). There are enormous possibilities and potential for the use of microorganisms to meet the growing global demand for food through the efficient use of available natural food, feed and the conversion of waste materials. In addition, the role of yeast in winemaking is the most critical element that distinguishes wine from fruit juice, and most industrial winemaking processes utilize the commercial wine yeast strain *Saccharomyces cerevisiae* (Kelebek et al., 2013). In the wine industry, grape juice, which contains 7.23 percent pulp, peels, stems and seeds, is often referred to as must in North America. Grapes, consisting of two varieties of Native American grapes, the European grape in California, sultanas (known there as seedless Thompson) are sometimes diverted from the table market to produce white juice (Somogyi, 2006). Fermented milk has been reported by several researchers as a good source for isolation of *Saccharomyces cerevisiae* for wine production. *Saccharomyces cerevisiae* is known for its role in food production. It is the critical component of the fermentation process that converts sugar into alcohol; an ingredient used in wine, beer, and distilled beverages. S.

cerevisiae can come in two different forms: haploid and diploid. It is usually found in the diploid form (Laundry *et al.*, 2006). Unique strains of *Saccharomyces cerevisiae* are involved in the fermentation of most fruits and vegetables, with high alcohol content, up to 20%, and acceptable taste and aroma (Jyoti and Kasipathy, 2010).

MATERIALS AND METHODS

Collection of Samples

Fresh purple and green grape fruits were bought at the Farmers Market in Maitama, Abuja, Nigeria. The fruits were transported in clean plastic bags to the Microbiology Laboratory of the Nile University of Nigeria. The selected grapes were stored at refrigeration temperature (4°C) (Haier Thermocool, Nigeria) for 24 hours before preparation and fermentation. Fresh fermented milk was collected in sterile bottles from Ruggar-Fulani, Abuja, Nigeria and transported in a cold pack with an ice pack to the microbiology laboratory at Nile University of Nigeria, Abuja for the isolation of yeast (*Saccharomyces cerevisiae*).

Isolation and Identification of Yeast from Fermented Milk

Sabouraud Dextrose Agar (SDA) (HIMEDIA) was prepared according to the manufacturer's instructions and supplemented with 50 mg / L chloramphenicol for selective enumeration of yeasts. Serial dilution of fermented milk was performed and inoculated using pour plate techniques. A pure culture was produced on yeast-glucose agar plates. The microscopic examination of the isolate was carried out using the wet mount method according to Thais and Danilo (2006).

Carbohydrates Utilization Test on Yeast Isolate from Fermented Milk

One percent (1) % each of glucose, fructose, sucrose, lactose, xylose, mannitol, raffinose, galactose and maltose sugar were prepared using yeast fermentation broth and 10 ml volumes were added to clean test tubes. Clean Durham tubes were inserted into the tubes, all bubbles displaced, and then autoclaved at 121 ° C for 15 minutes and allowed to cool. The sterile broth was inoculated with 0.2 ml of yeast culture broth and incubated at room temperature (27±1°C) for 72 hours and evidence of fermentation was observed through colour change and foam in the broth.

Pedifferences in raw material and other physical factors (temperature, humidity, etc.). The composition immediately after fermentation did not maintain the same pattern, with green grape wine being 94.33% and purple grape wine being 92.28%, which, according to Okaka (2010), is responsible for its high perishability and short shelf life under ambient temperature. Grapefruit also contained total carbohydrates (7.26%) and (6.85%), invariably responsible for their high calorie count, suggesting the presence of an energy source for the yeast's metabolic activity. The temperature rises recorded during the fermentation to produce wines may be due to the catabolic reduction of sugar by yeast cells resulting in increased temperature. The heat produced during fermentation as an exothermic process leads

to the temperature rising in the fermentation vessel.. This is in line with the reports by Balogu and Towobola (2016). In general, the lower the pH, the higher the acidity of the wine (Bellman and Gallander, 1979). Acetic acid is an organic acid with two carbon atoms that is produced in wine during or after fermentation. In this study it was observed that the post-fermentation specific gravity values steadily decreased in the range of 1.15 and 1.120 to 1.0002 and 1.003. The reduced volatile acidity may be due to the ethanol consumed during fermentation in the process, as reported by Gould *et al.* (1988). The percent alcohol content at the end of fermentation was measured as 10.5 and 10.2 for green and purple grapes, respectively. Similar results from Chilaka *et al.* (2010) must have shown an alcohol percentage between 10.14 and 12.8% during the fermentation of passion fruit, watermelon and pineapple fruits. However, according to Okunowo and Okotore (2005), this is comparable to moderate grape wine. High alcohol content are known to be important precursors for ester formation, which are associated with pleasant aromas (Clemente *et al.*, 2007). Microbial isolates were dominated by yeast isolates. The abundance of nutrients (sugar) in grapes make it a good breeding ground for microbial growth. This explains the apparently high prevalence of yeast among wine mixes. A similar report was made by Fleet (2007) and Lemet *et al.* (2016) with high prevalence of yeast and bacteria from alcoholic wine. There was a rapid increase in the number of viable yeast cells during the first hours (72 hours) of fermentation and a decrease afterwards. This increase in the number of yeast cells is due to the effective use of the available sugar component and the daily aeration of the fermentation must, which leads to rapid cell reproduction. This agrees with the results of Awe and Nnadozie (2015). The decrease in the number of yeast cells in the fermenting vessel could be due to the significant decrease in the sugar content as a result of the rapid and effective utilization of the sugar available in the must by the yeast cells, which leads to the fermentation of the must with a simultaneous increase in the alcohol content and the growth rate of the yeast, this is in conformity with the report of Awe (2011). The result of the microbial analysis showed that there were few or no microbial contamination of the wine after pasteurization. This shows the quality of the wine and implies that the wine was made under hygienic conditions and is safe for human consumption. A similar observation was reported by Adedeji and Oluwalana (2013). The fermentation was carried out under aseptic conditions in order to obtain a good fermentation yield and to ensure the stability of the entire fermentation process during the entire time. These precautions or measures could have been the reason why there were no impurities in the fermentation medium. The heat treatment (pasteurization) could also be another reason why there were minimal impurities. Thus the heat treatment was sufficient to destroy microbial contaminants in the wine. This is similar to the reports by Adedeji and Oluwalana (2013). The sensory evaluation rated the purple grape wine as preferable to the green grape wine. Purple grape wine received high ratings on all parameters (appearance, texture, aroma, taste), and overall acceptance, where the mean ratings were the same. The average rating for appearance by the Panel for wine made from green grapes was higher than that of wine made from purple grapes. This could be due to the absence of anthocyanins that give the purple grapes their natural color. There was no difference in the taste of the two wines, as it was attributed to their comparable increase in alcohol content, as reported by Duarte *et al.* (2010). The result of the microbial analysis showed that the wine made from purple grapes deteriorates faster than the wine made from green grapes, which could be due to the properties of purple wines with high phenol content (Somer and Evan 1997). Wines with a low phenol content are more prone to a loss of freshness, fruitiness and

an increase in browning due to oxygen. (Vidal and Aagaard, 2008). According to Lopes *et al.* (2005), oxygen is one of the most important factors that determine the aging potential of bottled wine. Depending on the phenol content, one liter of wine can absorb 60,600 ml of oxygen, but the wine ingredients are oxidized and the character of the wine is changed or even lost (Singleton, 1987). In red wines, a little oxygen can improve the color stability and reduce the astringency due to the polymer formation. Oxygen in white wines reduces desirable sensory properties and can therefore be an important factor in determining the shelf life of wines. According to Casey (1988), the eventual decline in wine quality is largely caused by the cumulative effects of the very gradual ingress of atmospheric oxygen as the permeability of traditional natural cork changes over time. The loss of cork elasticity reduces the sidewall force, which allows oxygen to penetrate through the glass cork interface. If the wine penetrates the cork, there is also evidence of changes in cork permeability, although no data is available on this. This situation is not limited to wines packed in glass bottles with cork stoppers, as oxygen can penetrate almost all packaged wines regardless of the type of closure or packaging material, albeit at different speed.

Table 1: Proximate Composition of Grape Wines

Parameters (%)	Samples:	
	GGW	PGW
Moisture content	94.33	92.96
Ash content	0.38	0.40
Protein	0.26	0.31
Crude fat	0.13	0.16
Crude fibre	ND	ND
Total carbohydrate	4.90	6.17

Key: GGW: Green Grape Wine, PGW: Purple Grape Wine, ND: not detected

Table 2a: Bacteriological Analysis of the Produced Grape Wine

Pasteurization	Bacteria count in wine samples:	
	GGW (CFU/mL)	PGW (CFU/mL)
Before	8.5x10 ⁶	4.9x10 ⁶
After	11 (TFTC)	7 (TFTC)

GGW: green grape wine, PGW: purple grape wine., CFU/ML: colony forming unit, TFTC: To few to count

Table 2b: Mycological (fungal) Analysis of the Produced Grape Wine

Pasteurization	Fungal count in wine samples:	
	GGW(CFU/mL)	PGW(CFU/mL)
Before	4.5x10 ⁶	3.0x10 ⁶
After	8(TFTC)	NGS

Based on the morphological features (cultural and microscopic) and the budding pattern, it was determined that the isolates belong to the *Saccharomyces* genera, supported by their ability to utilize maltose, fructose, galactose, sucrose, glucose, the organism was identified as *Saccharomyces cerevisiae* in agreement with the report by Mohammed *et al.* (2017) who reported

that fermented milk contained various types of yeast that were dominated by *S. cerevisiae*. The same yeast species identified in this research was isolated in other fermented milk studies. However, other previous studies using traditional milk fermentations generally found greater biodiversity compared to the results of this study. For example, in *Amasi* made from cow's milk (Gadaga *et al.*, 2000) reported identifying 20 different species, with *S. cerevisiae*, *Candida lusitanae*, *C. colliculosa*, *S. dairensis* predominating or in *Chal* made from camel milk (Yam *et al.*, 2015). It appears that the predominant species and biodiversity between different milk fermentations are different, probably due to

GGW: green grape wine, PGW: purple grape wine, NGS: no growth seen, CFU/ML: colony forming unit, TFTC: To few to count

Conclusion

This study showed that fermented milk is an excellent habitat for *Saccharomyces cerevisiae* to be isolated. The results of the fermentation show that quality wine can be made from grapes. The study also provided insight into the efficiency of microbes (local yeast strains) and the role of *Saccharomyces cerevisiae* in the alcoholic fermentation of grapes as good and acceptable substrates for wine production. This study has shown that it is possible to produce quality wines from grapes, as the microbiological quality enhanced the physiological and sensory properties of the wines

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BACTERIOTHERAPY OF PROBIOTICS ON SALMONELLOSIS (FEVER AND DIARRHEA) USING ALBINO RATS AS MODEL

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Abstract

This study assessed the therapeutic potentials of probiotics consortium (*Lactobacillus*, *Bifidobacterium* and *Streptococcus*) on symptoms (fever and diarrhea) and serological titre of albino rats induced with salmonellosis (*Salmonella typhi*). A total of 20 albino rats were grouped into 4 subsets designed as CTRL (Distilled water only), SISY (Salmonellosis induced + sterile yoghurt-base), SIWO (Salmonellosis induced without treatment), SIPT (Salmonellosis induced + probiotic treatment). Standardized *Salmonella* spp and probiotics consortium were administered daily at single dose (1 -2 mL) for salmonellosis inducement (14 days) and treatment (7 days) respectively. Physical parameters and serological assay were investigated and all data were subjected to statistical analysis ($p < 0.05$). Result showed that SIPT and SISY significantly ($P < 0.05$) reversed the weight loss due to salmonellosis. Among the treatments, only SIPT significantly reduced temperature to normal body temperature (35.5 – 37.2 °C). Physical signs of diseases were significantly ($p < 0.05$) reverted by SIPT with efficiency index of 9.9 (100%) and SISY 1.35 (60%), contrary to SIWO at 0.08 (0%). Serological titres for *Salmonella* spp antigens (A, B, C & D) were clinically diagnosed as negative ($< 1/160$) after treatment with SIPT with efficiency index of 9.9 (100%), while other treatments were beyond the clinical threshold ($> 1/160$). Thus, this study suggests that probiotics in synergy with standard drugs could effectively manage multi-drug antibiotic resistant salmonellosis cases.

Keywords: probiotics, *salmonella typhi*, serological assay, albino rats, diarrhea

Introduction

Probiotics are viable microorganisms that have functional properties and health benefit to both animal and human hosts when administered at adequate quantity (Balogu *et al.* 2017). Soothing effects of bacterial probiotics to gastrointestinal diseases and microflora when administered in adequate viable or dried form have been documented across the globe termed bacteriotherapy (Gopal *et al.*, 2001). Several studies have reported that probiotics have detoxifying effect on heavy metal blood toxicity (Balogu *et al.* 2017), growth and metabolic modulation (Pogačar *et al.*, 2022), anti-cancer and antibiotic properties against pathogenic organisms (Pogačar *et al.*, 2022) that are associated with gastrointestinal diseases symptoms. Among the efficient probiotics are lactic acid producing bacteria (LAB) from genus of *Lactobacillus*, *Bifidobacterium*, *Bacillus* and fungal species of *Saccharomyces cerevisiae* ssp *bouardii*. They have been documented to have successfully modulated immune stimulators, metabolic

and growth activities, inflammatory gastrointestinal diarrhea and enteric pathogens such as *Vibrio cholerae*, *E. coli*, *Shigella* and *Salmonella* spp (De Keersmaecker *et al.*, 2006).

Diarrhea and fever are peculiar of gastrointestinal disease symptoms associated with microbial agents (bacteria, virus and parasites) and it is characterized by frequent loose stool (at least for 2 consecutive days) with or without mucus and blood. *S. paratyphi* and *E. coli* are prominent bacterial species that cause diarrhea in children and adults. Basically, diarrhea manifests in varying severity based on four mechanisms categorized as osmotic, inflammatory, secretory and motility-related (traveler's disease) diarrhea. The difficulties to manage diarrhea cases in infant after weaning with antibiotics are due to antibiotic-induced diarrhea as side effects (Alam and Shtaq 2009). This factor makes the prospects of managing diarrhea with probiotics a worthy alternative to health stakeholders. Though most documented claims of therapeutic properties of probiotics were investigated at the *in vitro* setup, and for this reason, it is necessary to reevaluate these claims in *in vivo* (animal models). The objective of the study was to evaluate the therapeutic properties of probiotics from yoghurt against key salmonellosis symptoms in animal model (Albino rats).

Methodology

Animal model (Albino rats)

A total number of 20 healthy and active albino rats were randomly selected from animal repository of Ibrahim Badamasi Babangida University Lapai (IBBUL), Nigeria after 7 days acclimatization. During this period, they are fed with poultry feed (grower's mesh), drinking liquid (50% water + 50% sterile yoghurt-base), ventilated ambient temperature (20-25°C) in plastic cage (190 cm²/rat). This protocol was standardized during 14 days Salmonellosis (typhoid) inducement and 7 days treatment. Periodic weight of the animal models was monitored with 5kg electronic compact scale (SF-400A, India).

Probiotic and salmonella stock culture formulation

All pure isolates were obtained from bacterial repository at Centre for Applied Sciences and Technology (CASTER), Ibrahim Badamasi Babangida University Lapai (6.34° 44E, 9.03° 36N) and verified with MRS agar (Probiotics) and Salmonella-Shigella agar (SSA) for *Salmonella* spp using standard protocols (Chesbrough, 2009). Identified probiotics consortia (*Lactobacillus*, *Bifidobacterium* and *Streptococcus* spp) and *Salmonella* spp were each primed in 500mL sterile yoghurt-based broth for 24-48h prior administering to animal models (albino rats). The stock cultures were standardized to ~8 log cfu/mL (probiotics consortium) and ~6 log cfu/mL (*Salmonella* spp) and designed as PT and ST respectively.

Experimental design

The randomly selected 20 healthy and active albino rats were grouped into 4 (5 rats for each group) designed as control (Distilled water only), SISY (Salmonella induced + sterile yoghurt-base), SIWO (Salmonella induced without treatment), SIPT (Salmonella induced + probiotic treatment). All subgroups were induced with salmonellosis and they showed significant clinical (serological titre 1/160), signs and symptoms of infection prior treatment except the control

group. The salmonellosis induced rats were tagged as BT (Before treatment) and AT (After treatment).

Salmonellosis Inducement (TYPHOID) and administration of treatment

Salmonellosis typhoid fever was induced in the albino rats by administering a single dose (2mL) of ST (6 log₁₀ cfu/mL) orally for 7 days (~168hrs) and observed for positive significant signs and symptoms of salmonellosis. Probiotic treatment protocols were administered as a daily oral single dose (1mL) of PT (8 log₁₀ cfu/mL) for 14 days (~336hrs) as described by Baloguet *al.* (2017).

Physical parameter and stool analysis of albino rats

All sampled albino rats were observed for physical changes such as temperature, hair orientation and stool texture. Each daily stool irrespective of their texture (watery or not) was investigated for the presence of *Salmonella* spp. Exactly 1g of stool was diluted in 9mL of distilled water (0.1g/mL) and 1 mL aliquot of this solution was pour-plated on SSA media at 37°C for 24h to investigate the presence of *Salmonella* spp, enumerated by plate count and, characterized with morphology and biochemical assays (Chesbrough, 2009).

Serological assay for presence of *Salmonella typhi* (A, B, C & D) in albino rat blood

Within 24h after the last day of the 14-day treatment, each rat was weighed, sacrificed and 5 mL of blood collected through cardiac puncture into EDTA bottle. Serum of the blood samples (centrifuged after 1h stand to clot) were collected and used to assay for the presence of *S. paratyphi* Antigens (D) and *S. paratyphi* (A, B and C) using a rapid test protocol (Chesbrough 2009). Positive results were taken at $\geq 1/160$ titre value (titre value for significant symptoms of fever and diarrhea).

Ethical consideration of animal models

Ethical standards of IBB University guidelines regarding animal usage for research purpose were strictly adhered to and monitored by the committee. Key ethical issues addressed were adoption of minimal valid animal population, distress, pain and death of the model.

Statistical analysis

Generated data were subjected to variance analysis tools of post hoc multiple comparison and Duncan multiple range using Statistical programme for Social Sciences (SPSS) version 23, IBM, Inc, USA. Results were expressed as mean value of triplicate values. Efficiency index ratio (E_i) of probiotics treatments were calculated to estimate the significance of probiotics treatment to ameliorate the salmonellosis signs and systems in rats using protocol adopted from Baloguet *al.*, (2014).

$$E_i = \frac{[0.1(S_i - 1) + 1]}{[0.1(R_i + 1) + 1]} = \frac{[S_i + 9]}{[R_i + 11]}$$

Where S_i = specific positive rate (%); R_i = resistance rate (%) = $[100 - S_i]$

$E_I > 1$ = significant; $E_I < 1$ = not significant

Result and Discussion

Table 1 result showed that only SIWO (170.9 – 177.1g) and control groups CTRL (192.2 – 199.6g) had no significant ($p > 0.05$) changes in body weights prior and after treatment period of 14 days. Interestingly, SIPT (172.0g to 193.2g) and SISY (178.4 – 202.2g) significantly ($p < 0.05$) reversed the weight loss caused by salmonellosis. The high mean temperature range (44.5°C) observed in SIPT was significantly reduced to normal (37.3°C) which is similar to the control group (35 – 37.5°C). Rotimi *et al.*, (2012) observed a similar pattern in body weight and temperature changes of salmonella infected rats treated with amoxillin and pefloxacin. However, SISY treated rats had numerical temperature decline from 43.3°C to 39.3°C. Salmonellosis induced rats treated with SIWO maintained relatively high temperature (45.3 – 44.7°C) throughout the treatment period, indicating febrile condition which is a key sign of salmonellosis (CDC 2013). Physical signs of diseases (loose/erect hairs and soft/mucous fecal matters) and stool cultures were visibly reversed to normal conditions after treatment with probiotics (SIPT), while SISY only reversed the abnormal loose/erect hair. Perhaps, the functional, nutritional and metabolic modulating properties of probiotics/yoghurt-base were responsible for the restorative impact. However, SIWO had no positive impact on the visible signs of salmonellosis in the rats. the control group showed no sign of abnormality prior and during treatment. Stool culture assessment showed that only SIPT and SISY had complete elimination of *Salmonella* sp from the fecal matter of treated rats unlike SIWO groups that still had traces of *Salmonella* sp presence in the stool. Efficiency index of different treatments on the signs and symptom (physical and fecal matter) of salmonellosis management, showed that SIPT had the highest significant ($p < 0.05$) efficiency index of 9.9 equivalent to 100%, followed by SISY with 1.35(60%) and SIWO index was not significant ($p > 0.05$) at 0.08 (0%).

The serological assessment of the salmonellosis induced rats treated with probiotics (SIPT) had a significant ($p < 0.05$) reduction on the typhoid with negative widaltitre value ($< 1/160$) for all the antigens (A, B, C and D) with efficiency index of 9.9 (100%) as shown (Table 2). However, sterile yoghurt-base treatment (SISY) had a poor efficiency index 0.46 (28.6%). Control groups CTRL and SIWO rats were diagnosed nil (negative titre $< 1/160$) and infection (positive titre $\geq 1/160$). This study and Anthony *et al.*, (2002) shared similar opinion that absence of signs and symptoms or negative titre value ($< 1/160$) does not indicate the absence of the *Salmonella* spp pathogen in the rats. This means that *Salmonella* spp could be endemic in the blood of rats without any manifestation of signs and symptoms of disease.

Table 1: Physical parameter and Stool analysis of Albino rats

Albino rats group	weight(g)		Temperature (oC)		Loose and erect hairs		Soft and mucous fecal matter		Stool culture		Probiotic Efficiency index [E_I] (%)
	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	
CTRL	192.2 $\pm$ 2.6 ^a	199.6 $\pm$ 1.6 ^a	37.5 $\pm$ 0.4 ^a	35.5 $\pm$ 1.1 ^a	-	-	-	-	-	-	Nil
SISY	178.4 $\pm$ 4.5 ^b	202.2 $\pm$ 2.4 ^a	43.3 $\pm$ 0.4 ^b	39.3 $\pm$ 0.7 ^b	+	-	+	+	+	-	1.35(60%)
SIWO	177.1 $\pm$ 5.4 ^b	170.9 $\pm$ 1.9 ^b	45.3 $\pm$ 3.5 ^b	44.7 $\pm$ 0.2 ^b	+	+	+	+	+	+	0.08(0%)

SIPT	172.0±4.5 ^b	193.2 ±1.7 ^a	44.5 ±2.8 ^b	37.3 ±3.0 ^a	+	-	+	-	+	-	9.9 (100%)

Key: **CTRL**= Control (No treatment), **SISY**= *Salmonella* induced + sterile yoghurt-base, **SIWO** = *Salmonella* induced + water only,

SIPT = *Salmonella* induced + probiotics treatment. **BT** = before treatment, **AT** = After treatment. **Positive (+)** = $\geq 40\%$ of rats' subgroup ($n=5$) manifests signs, **Negative (-)** = $< 40\%$ of rats' subgroup ($n=5$) manifests sign. $E_I \geq 1$ = significant; $E_I < 1$ = not significant.

**Values are means $\pm$ Standard Deviation of triplicate values.Means in column with the same superscripts are not significantly ($p>0.05$).

Table 2: Serological assay for presence of *Salmonella sp* (antigens: A, B, C and D) in albino rat's blood treated with probiotics

Albino rat groups	Antibodies	<i>Salmonella Para typhi</i>				<i>Salmonella typhi</i>				Diagnosis		Probiotic Efficiency index[E _I] (%)
		A		B		C		D		BT	AT	
		BT	AT	BT	AT	BT	AT	BT	AT			
CTRL	O/H	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	Nil	Nil	Nil
SISY	O/H	+/+	-/-	+/-	-/-	+/+	+/+	+/+	+/+	Infection	Infection	0.46(28.6%)
SIWO	O/H	+/+	+/+	-/+	-/+	+/+	+/+	+/+	+/+	Infection	Infection	0.08 (0%)
SIPT	O/H	+/+	-/-	+/-	-/-	+/+	-/-	+/+	-/-	Infection	Nil	9.9 (100%)

Key: **CTRL**= Control (No treatment), **SISY**= *Salmonella* induced + sterile yoghurt-base, **SIWO** = *Salmonella* induced + water only,

SIPT = *Salmonella* induced + probiotics treatment. **BT** = before treatment, **AT** = After treatment. **O/H** = Salmonella antibodies “O” & “H”, (**A, B, C and D**) = Salmonella para typhi and S. typhi antigens. **Positive (+)** =Agglutination/titre values $\geq 1/160$, **Negative (-)** = No agglutination/titre values $\leq 1/160$. $E_I \geq 1$ = significant; $E_I < 1$ = not significant. **** Minimal titre value $\geq 1/160$** ensures significant salmonellosis symptoms (fever and diarrhea) in rats.

Conclusion

Findings of this study showed that probiotics have a significant impact on managing the signs and symptoms (fever, diarrheal and clinical serological titre value) of salmonellosis. Thus, considering the multi-drug resistant of salmonellosis to antibiotics, the findings of this study suggests that probiotics (adequate quality and quantity)in synergy with standard drugs could be more effective approach to managing salmonellosis.

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SURVEY OF AFLATOXIN LEVELS IN MAIZE AND COWPEA SOLD IN IDDO GRAIN MARKET, LAGOS, LAGOS STATE, NIGERIA

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Abstract:

Two pre-survey visits to assess the aflatoxin contamination levels in white black-eyed cowpea and white maize were made at Iddo market in Lagos between 2017 and 2020. The market survey was carried out using rapid rural appraisal (RRP) method; participatory mapping, triangulation tools, and purchasing of commodities samples. White maize and white black-eyed cowpea samples were randomly purchased from thirty (30) different stalls, placed in transparent Ziploc bags. Each sample weighed 700g and 650g respectively. Triangulation pointed out that aggregators lacked requisite knowledge on how to mitigate the problems of aflatoxin. Proximate and microbial analyses were evaluated to determine the influence of moisture content and presence of molds on the levels of aflatoxins, while the reducing effect of processing methods on the aflatoxin levels in the samples were assessed. Enzyme-linked immunosorbent assay (ELISA) for detection and quantification of total aflatoxin levels were assessed using RIDASCREEN® Aflatoxin Total.

The aflatoxin contents of the unprocessed samples of maize and cowpea ranged from 3.7 - 9.8 ppb while that of processed maize and cowpea samples ranged from 2.0 - 3.4 ppb. Total aflatoxin contents in unprocessed samples were significantly ($P < 0.05$) higher than the processed whole grains. Thus, indicating that grain processing (washing and drying) significantly decreased ($P < 0.01$) the aflatoxin levels by more than 77%. There is need for regular surveys of our agricultural produce in markets by the Institute for surveillance, detection and analysis of aflatoxins in foods and feeds for enhanced quality of the produce consumed within our country, for update on information for database to both researchers and government in policy decision making.

Key Word: Survey, aflatoxin, grains processing, ELISA method, Multi-crop dryer.

Introduction

The ban by the European Union (EU) of some Nigerian agriculture produce is not new and can be traced to high level of pesticide residues, metal contaminations, poor packaging, aflatoxin contamination in the produce and products for export (NSPRI 2015). In Nigeria, the presence of Aflatoxins (B1, B2, G1, G2, M1 and M2) have been detected in maize,

cowpea, groundnuts, products (Atehnkengetal., 2008). Aflatoxins are secondary metabolites produced by the fungal strains *Aspergillus*.

The optimum condition for growth and subsequent production of aflatoxins by *Aspergillusflavus* include, moisture content above 14%, optimum temperature of 28-30°C, and water activity of 0.83-0.97. The oxygen to carbon dioxide ratio, physical integrity of the grain, initial levels of mold infestation, pest activity and generic properties of the grain also determine the degree of contamination (Diener, *et al.*, 1987).

The need to analyze the proximate and microbial contents on the grain samples in order to determine the influence of moisture content and presence of molds on aflatoxin levels and assess the influence of processing methods (washing and drying) on the reduction of aflatoxin levels present in white black-eyed cowpea and white maize sold in Iddo market in Lagos metropolis necessitated the institute to carry out these surveys.

Materials and Methods

Market surveys

In 2017 and 2020 market surveys were carried out on dates agreed with the markets leaders using rapid rural appraisal (RRP) method; participatory mapping, triangulation tools applying the methodology employed by Mohd, *etal.*, (2012) in line with FAO (1997) guidelines and purchasing of commodities samples. Within the geographical location of the market, survey commodities with aggregators/traders were mapped into major commodities and assigned to two multi-disciplinary groups of cowpea and maize. With adequate knowledge of principles of RRP, commodities aggregators/traders were not rushed, but listened to, and probed instead of passing onto the next topic to reveal more information on possible causes and prevalence of aflatoxin in the market. Each multi-disciplinary group had the sample materials (transparent Ziploc bags) properly labeled before the commencement of the surveys.

Sampling for analysis

White maize and white black-eyed cowpea samples were randomly purchased from thirty (30) different stalls in Iddo market listed in the study area and transported in transparent Ziploc bags properly labeled to Entomology Laboratory, NSPRI Zonal Office, Lagos. Each sample weighed approximately 700g and 650g respectively. In the laboratory, the samples were cleaned by sieving, handpicking to remove stones, discolored grains, other extraneous materials. Wholesome and damaged grains, and the number of insects were recorded. The wholesome cowpea was bulked and mixed thoroughly in order to obtain a homogenous mixture. Similar method was applied to the white maize. The conning and quartering method was employed in order to get an appropriate representative sample of each 300g cowpea or maize for analyses.

The representative samples of each cowpea and maize grains were subjected to proximate analysis determined according to the standard analytical method by the Association of Official Analytic Chemist (AOAC, 2005), microbial count was determined using the method of (Schlegelova, *etal.*, 2010) modified.

Sample Preparation for aflatoxin

30g representative sample of each maize and cowpea grains were washed, sun-dried and then further dried in the NSPRI Multi-crop dryer and 10g taken labeled processed maize and cowpea separately.

In the Biochemistry laboratory 10g of the representative sample of each unprocessed maize and cowpea were milled and extraction method according to Atehnkeng *et al.*, (2008) was followed and homogenization followed according to standard procedures.

Total Aflatoxin Content Determination

Assay procedure was followed according to the protocol provided by RIDASCREEN® Aflatoxin Total (ART. No. R4701, R-Biopharm AG, Darmstadt, Germany).

All analysis in duplicates. Standard solutions were prepared for Total aflatoxin calibration curves. The lower concentrations were 0.05ppb, whereas the higher concentrations were 4.05ppb. Samples that were beyond the range of the highest standard concentration were diluted, and the ELISA experiments were repeated. The Total aflatoxins content of each sample was calculated using the prepared standard curve.

Total Aflatoxin Validation

The validation of ELISA methods was carried out with the determination of the recoveries and the coefficient of variation (%CV). A specific software, the RIDA® SOFT Win.net(ART No. Z9996) evaluated and analyzed the total Aflatoxin data.

Statistical Analysis

The data obtained for proximate composition were analyzed for central tendencies (mean) and expressed as mean $\pm$ standard deviation of the observations. T-test excel formula was used to ascertain significant differences ($P < 0.05$) in the parameters between the grains.

Results and Discussion

Market Survey

Participatory mapping tool engaged in the surveys revealed different aggregation sections in the market which include articulated vehicles/trucks, containerized export food, bagged commodities wholesales, baskets commodities wholesales, and government approved retail measurements. Mapping further revealed five entry and exit routes which include two big gated for movement of articulated vehicles and three pedestrians' entry and exit points. Triangulation helped to compare and complement information from different sources (aggregation sections) which pointed out that aggregators had positive perception and good understanding on the problems of aflatoxin. However, they lacked requisite knowledge on how to mitigate or at best avoid the health hazards. Information on sources of commodities showed that cowpea and maize were purchased mainly from Kaduna and Yobe states.

The results of proximate and microbial analyses are showed in Table 1. The proximate content showed that white maize grain sample from Iddo market had moisture content of 6.44%, while that of black-eyed cowpea was 5.29%. Percentage carbohydrate content of the analyzed white maize sample (68.37%) and the cowpea (52.76%). Crude protein content for white maize 9.84% and black-eyed cowpea (18.38%). The result of the crude fat content obtained in this study, showed that the white maize had (5.02%), while the black eyed cowpea had a higher

crude fat (15.27%) as shown in Table 1. The values of the black-eyed cowpea and the white maize were slightly similar to the report on cowpea 14.15% and maize 4.07% (Ekhuemelo and Abu, 2018).

There was no significant difference ($P > 0.05$) between the crude ash of black-eyed cowpea (1.06%) and white maize (1.06%) of the analyzed samples. This is lower than 2.19% recorded by (Ape, *et al.*, 2016). The crude fibre content of the black-eyed cowpea was 7.24% and white maize 9.27%.

The white maize and black-eyed cowpea samples analyzed in this study had fungal loads that were below the ICSMF official limit which means they did not exceed the standard of 10^5 cfu/g of food and are microbiologically safe for consumption.

The preparation procedure in the immune-enzymatic methods is very simple as it consists mainly in extraction and there is no need for purification or isolation of the tested component. Aflatoxin contents of the unprocessed samples of maize and cowpea ranged from 3.7 - 9.8 ppb as shown in Table 2. While that of samples selected for processing maize and cowpea ranged from 2.0 - 3.4 ppb. Total aflatoxin contents in unprocessed samples were higher than in the corresponding processed whole grains. Washing and drying the grains significantly decreased ($P < 0.001$) aflatoxin levels from between 3.7 - 9.8 to between 2.0 - 3.4 ppb, EU has the strictest standards, such that any products for direct human consumption can only be marketed with the maximum permissible level for total aflatoxins concentration in unprocessed foods as < 4 ppb and for processed food as < 2 ppb (European Commission-EC, 2007; 2010). Therefore, the Total aflatoxin content of the unprocessed maize and processed maize analyzed in this study were above the permissible limits. While the Total aflatoxin content of the unprocessed cowpea and processed cowpea were below permissible limit set by EU for consumption.

Table 1: Showing the result for proximate and microbial contents of maize and cowpea.

Proximate	White Maize	Black eyed Cowpea
Composition(g/100g)		
Moisture	6.44 $\pm$ 0.00	5.29 $\pm$ 0.08
CHO	68.37 $\pm$ 0.02	52.7 $\pm$ 0.24
Protein	9.84 $\pm$ 0.01	18.38 $\pm$ 0.16
Crude Fibre	5.02 $\pm$ 0.03	15.27 $\pm$ 0.14
Ash	1.06 $\pm$ 0.02	1.06 $\pm$ 0.03
Crude Fat	9.27 $\pm$ 0.06	7.24 $\pm$ 0.04
Microbial analysis		
	Colony count for	Colony count for Black eyed

Parameters	White Maize	Cowpea
Yeast	ND	ND
Mold	1.65x10 ⁴	9.0x10 ³
Official Limit (ICMSF)	NMT 10 ⁵ (mold)	NMT 10 ⁶ (yeast)
Unit	Cfu/g	Cfu/g
Fungi Morphology	<i>Aspergillus</i> Sp. /ND (mold) / (yeast)	<i>Penicillium</i> Sp. / ND (mold) / (yeast)

**** Values for proximate are means of three determinations $\pm$ the respective standard deviations.**

**** ICMSF – International Commission on Microbiological Specification for Food**

**** ND – Not detected**

Table 2: Showing the result for the sample

Serial No	Standard Concentration (ppb)	Absorbance			Calculated (ppb)	Dilution Factor	Final Calculated (ppb)
		Mean	CV	%			
1.	Unprocessed Maize	2.915	0.2	91.2	0.28	35.00	9.8
2.	Processed Maize	2.999	4.1	93.8	0.096	35.00	3.4
3.	Unprocessed Cowpea	2.986	3.3	93.4	0.11	35.00	3.7
4.	Processed Cowpea	3.083	0.8	96.4	0.057	35.00	2.0

Conclusion:

From the study, processing of grains by washing and drying before use for consumption reduced the aflatoxin levels. There is need for regular surveys of our agricultural produce in markets by the Institute for surveillance, detection and analysis of aflatoxins in foods and feeds for enhanced quality of the produce consumed within our country, for update on information for database to both researchers and government in policy decision making.

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MICROBIOLOGICAL QUALITY AND SAFETY OF SMOKED CATFISH (*Clarias gariepinus*) DURING STORAGE

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ABSTRACT

The study was carried out to determine the microbiological quality and safety of smoked catfish (*Clarias gariepinus*) during storage. Sixty samples of fresh catfish were purchased at Odogunyan market, Ikorodu. The samples were divided into four portions vis-a-vis samples smoked with wood for 1h and 30 min at 120°C (ADF), samples smoked with wood for 1h 45 min at 105°C (PAS), samples smoked with charcoal for 2h at 89°C (FAD) and smoked with charcoal for 2h 15 min at 85°C (SPA) respectively. Microbiological analyses were carried out on the smoked catfish samples to determine the presence of pathogenic bacteria using standard methods. The results showed the presence of 3 general of bacteria: *Bacillus spp*, *pseudomonas spp* and *flavobacterium spp*, one general of coliform: *Aeromonas spp* as well as 3 genera of fungi: *Aspergillus spp*, *Penicillium spp* and *Rhizopus spp*. The total bacterial and fungal counts ranged from 1.2×10^2 - 9.6×10^4 and 3.2×10^2 - 9.9×10^4 respectively in the samples over a period of 15 days. The ICMSF protocol recommended maximum bacterial counts of 5×10^5 and maximum count of 10^7 for marginally acceptable quality products. The results revealed that the smoked catfish samples were still within the range stipulated for good product by ICMSF.

Key words: Smoked catfish, microbiological, quality, safety

INTRODUCTION

Fish is an important source of food and income to many people in the developing world. In Africa, some 5% of the population, about 35 million people, depend wholly or partly on the fisheries sector for their livelihood. Fish harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries (Al-Jufaili and Opara, 2006).

Fish undergoes rapid deterioration after harvesting and spoilage occurs as a result of the action of enzymes (autolysis) and bacteria present in the fish and also chemical oxidation of the fat which causes rancidity. At the high temperatures prevalent in tropical countries like Nigeria, bacterial and enzymatic actions are enhanced (Khoshmanesh, 2006). Fish invariably becomes putrid within a few hours of capture unless they are preserved or processed to reduce this microbial and autolytic activity and, hence, retard spoilage. In order to extend the shelf life of

fish after harvesting and during storage several preservative techniques are used such as curing, smoking and drying (Adeyeye *et al.*, 2016). Curing and smoking processes of fish help product stabilization through antimicrobial effects of the smoke as well as the water activity reduction due to moisture loss (Adeyeye *et al.*, 2016).

Some fish processing methods that are commonly used include fermentation, drying, frying, canning, salting and smoking (Adeyeye *et al.*, 2016). Smoking could be done in different ways such as cold-smoking which involves the use of little fuel-wood that produces low heat and the products obtained may not keep long due to high moisture contents. Hot-smoking involves use of much more heat and requires more energy in terms of fuel-wood (Adeyeye *et al.*, 2016). The smoked fish from hot-smoking are tastier due to the impact of the smoke and high temperature and better shelf-life (Adeyeye *et al.*, 2016).

Several studies have been carried out on the microbiological safety of fish by different researchers. Adebayo-Tayo *et al.* (2006) had reported the presence of Aflatoxin B1 and G1 in high concentrations in fish and concluded that smoked dried fishes stored for sale in Uyo markets, Nigeria were heavily contaminated with aflatoxigenic fungi. Fafioye *et al.* (2002) studied the fungal infestation of five traditionally smoked dried freshwater fish in Ago-Iwoye, Nigeria, isolated and identified 11 different fungal species, of which *Aspergillus flavus* was the most frequently encountered fungi on the fish species. Adeyeye *et al.*, (2016) reported the presence of *Listeria monocytogenes* in traditional drum-smoked fish samples from Lagos State, Nigeria. But studies are scanty on the impact of smoking and storage conditions on the microbial quality and safety of catfish. Therefore, this study was carried out to investigate the effects of smoking and storage conditions on the microbiological quality and safety of smoked catfish (*Clarias gariepinus*).

MATERIALS AND METHODS

Source of materials

Fresh catfish (*Clarias gariepinus*) samples used for this study were purchased from Odogunyan market, Ikorodu. Wood and charcoal as well as other materials like salt, knife, bowl (small and big sizes) were also obtained from the same market.

Methods

Preparation of samples (smoking of fish)

Fish samples were smoked according to the drum smoking method described by Adeyeye, *et al.*, 2016. The fishes were slaughtered and then gutted, washed and salted and was left for some minutes. The samples were divided into four portions. The first and second portions were smoked with charcoal for 2hrs at 89°C (FAD) and 2h 15 min at 85°C (SPA) respectively. The third and fourth portions were smoked with wood for 1h and 30 min at 120°C (ADF) and 1h 45 min at 105°C (PAS) respectively. A thermometer was installed in the smoking chamber to monitor the temperature. This was done to determine the effects of smoking methods, fuel and time on the quality of smoked fish. The smoked fish samples were kept in a desiccator to cool, packaged in Ziploc bags and kept at ambient temperature for 24 h until laboratory analyses were carried out.

Microbiological Analysis of Water

(a) Sample collection

Glass bottles were washed with distilled water and sterilized. Two drops of 1.8% sodium thiosulphate were added to the bottles before sterilization with chlorinated water. The nozzles of taps were flamed and water was allowed to flow for some time before collecting it.

(b) Media Preparation and Sterilisation

MacConkey broth and Nutrient agar were rehydrated with distilled water. Broths were dispensed into MarCartney bottles containing inverted Durham tubes and sterilized in autoclave at 15psi for 15 minutes after the temperature had reached 121°C. Then, the broths were cooled to room temperature to avoid decomposition of sugars by prolonged exposure to heat.

(c) Sample Preparation of smoked fish samples

Smoked fish samples were subjected to microbiological analyses. The microbiological procedures used were those recommended by the International Commission on Microbiological Specifications for Foods (ICMSF, 1986). Culture media were those of Oxoid and Biolife. For each sample, 25 g were weighed out and transferred to a sterile blender with 225 mL of 0.1 % peptone water and mixed thoroughly for 2 minutes to prepare fish homogenate. Samples were mixed by inverting the bottles several times to disperse any sediment. The mouth of bottles was flamed when opened with spirit lamp to prevent contamination.

(d) Coliform Counts using the Multiple-tube Fermentation Technique

Presumptive test: Five mL of water was measured and diluted to McCartney bottles containing sterile MacConkey broths (double and single strength) using sterile pipettes and was incubated at 37°C for 24 hours. The number of bottles giving positive tests in terms of production of acid were noted (i. e those indicated by change in purple colour of the broth to yellow and produced gas in the inverted Durham tube). A consecutive series of three ten-fold dilutions which showed some positive and negative reactions were selected and multiplied the MPN by the dilution factor. This was reported as Most Probable Number (MPN) of total coliforms present in 100 mL of water sample estimated from the MacGrandy's statistical table. (Estimate of the mean density of coliforms in the sample).

Confirmed test: Coliforms present were confirmed whether they are of faecal origin. Each of the tubes was sub-cultured into Brilliant Green bile broth in MarCartney bottles containing inverted Durham tubes using an inoculating loop. Production of gas in the Durham tube after incubation at 44°C within 18-24 hours indicated a positive reaction and hence the probable presence of *E. coli*. The MPN of *E. coli* was estimated from the statistical table.

(e) Total Plate Count using the pour plate method

One mL of the sample was dispensed and diluted into a sterile petri dish using a sterile pipette. Sterile nutrient agar (15 – 20 mL) was added and mixed thoroughly by swirling gently. It was incubated at 37°C for 24 hours and the number of colonies growing in the agar plate was counted.

Statistical Analysis

Data were collected in triplicates and then subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS Version 20.0 software, 2011). Where significant differences existed, Duncan Multiple Range Test was conducted.

RESULTS AND DISCUSSION

Table 1 showed the total viable counts of bacterial, coliform and coliform isolates and organisms identified in the smoked fish. The value of bacterial isolates in the smoked fish ranged from 3.2×10^2 - 8.9×10^4 , 4.7×10^2 - 9.3×10^4 , 8.6×10^2 - 9.6×10^4 and 9.2×10^2 - 9.9×10^4 CFU/g from day 0 - day 15 for samples ADF, FAD, PAS and SPA respectively. *Bacillus spp*, *Pseudomonas spp* and *Flavobacterium spp* were the bacteria identified in the samples. There was no coliform isolates in all the samples except for sample ADF which ranged from 2.6×10 - 8.0×10 CFU/g from day 6 - day 15. The coliform identified in sample ADF was *Aeromonas spp*. The values of fungal isolates in the smoked fish were 1.2×10^2 - 7.5×10^4 , 4.5×10^2 - 7.9×10^4 , 8.3×10^2 - 8.9×10^4 and 8.9×10^2 - 9.6×10^4 CFU/g from day 0 - day 15 for samples ADF, FAD, PAS and SPA respectively. The fungal identified were *Penicillium spp*, *Aspergillus spp* and *Rhizopus spp*.

The present study revealed the presence of 3 general of bacteria: *Bacillus*, *pseudomonas* and *flavobacterium*, 1 general of coliform: *Aeromonas* as well as 3 genera of fungal: *Aspergillus*, *Penicillium* and *Rhizopus*. The occurrence of *Aspergillus spp*, *Rhizopus spp.*, and *Penicillium spp*. in the smoked fish species could be due to the fact that during storage, the fish sample reabsorbed moisture from the environment which then supported the growth of the microorganisms in addition to the contamination during processing, handling and display on the market stalls (Christianah *et al.*, 2010). The fungi species isolated are active decomposer and fermenters. Their presence on the fish suggested gradual degradation and deterioration of the nutritional quality of the fish as reported by Ohalet *et al.* (2019). This established the fact that when the fish samples are not consumed within a reasonable short time, these organisms may totally spoil them which was observed in sample ADF which showed sign of spoilage after day 3. The microbes isolated in this study were similar to the microbes isolated by Ohalet *et al.* (2019) who worked on microbial quality of fried and smoked fish in Owerri, Imo State Nigeria.

The total bacterial count and fungal count ranged from 1.2×10^2 - 9.6×10^4 and 3.2×10^2 - 9.9×10^4 CFU/g respectively in the samples over a period of 15 days. The ICMSF protocols recommend a maximum bacterial count of 5×10^5 CFU/g for good quality product and a maximum count of 10^7 for marginally acceptable quality products (ICMSF, 1986). Table 1 revealed that bacterial growth in all the samples were lower than 5×10^5 , which indicates that the smoked fish are of good quality even on day 15. Although, if these samples are not consumed after 15 days, it is expected that the microbial load would multiply tremendously and reach infective level thereby making the fish unfit for human consumption. Coliforms are called 'Sanitary Index' organisms whose presence in food in large quantity indicates the probability of culturing the organism in unhygienic condition or the usage of polluted water during processing (Feng *et al.*, 2002). Nyarko *et al.* (2011) reported total coliform bacteria in smoked sardine (*Sardinella aurita*) which ranged from 0.0 to 2.1×10^4 CFU/g in three smoking sites while 4.7 to 2.0×10^2 CFU/g in three marketing centres of Tema municipality, Ghana which is higher than the value reported in this study. The results presented in Table 1 heralded

the fact that the coliform count in sample ADF could be due to post smoking contamination not related to the production process.

CONCLUSION

In conclusion, the initial (day 0) results of this study showed that the samples were of good and wholesome quality for immediate consumption, however the microbiological quality of the samples during the storage progressively declined. The presence of 3 general of bacteria: *Bacillus spp*, *pseudomonas spp* and *flavobacterium spp*, one general of coliform: *Aeromonas spp* as well as 3 genera of fungi: *Aspergillus spp*, *Penicillium spp* and *Rhizopus spp* are of great concern. The total bacterial counts ranged from 1.2×10^2 - 9.6×10^4 CFU/g and fungal counts ranged from 3.2×10^2 - 9.9×10^4 in the samples over a period of 15 days and these values were below the recommended values for acceptable products by International Commission on the Microbiological Specification of Foods(ICMSF). The ICMSF protocol recommended maximum bacterial counts of 5×10^5 for good quality product and maximum count of 10^7 for marginally acceptable quality products. These revealed that the smoked catfish samples are still within the range stipulated for good products by ICMSF.

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1 Table 1: Total microbial count and organisms identified in smoked fish over a period of 15 days

Sample	Weeks	TVC	Org. Identified	TCC	Org. Identified	TFC	Org. Identified
ADF	0	3.2 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		1.2 x 10 ²	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
	3	7.2 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		4.8 x 10 ²	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
	6	4.5 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	**2.6 x 10	<i>Aeromonas spp.</i>	2.5 x 10 ³	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
	9	9.6 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	**4.6 x 10	<i>Aeromonas spp.</i>	8.5 x 10 ³	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
	12	3.8 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	**5.8 x 10	<i>Aeromonas spp.</i>	2.5 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
	15	8.9 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	**8.0 x 10	<i>Aeromonas spp.</i>	7.5 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Penicillium spp.</i>
FAD	0	4.7 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		4.5 x 10 ²	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	3	7.9 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		7.5 x 10 ²	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	6	6.0 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		4.0 x 10 ³	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	9	1.1 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		9.2 x 10 ³	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	12	6.2 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		3.9 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	15	9.3 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		7.9 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
PAS	0	8.6 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		8.3 x 10 ²	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	3	9.6 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		1.2 x 10 ³	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	6	7.4 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		5.5 x 10 ³	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	9	2.7 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		9.7 x 10 ³	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	12	5.7 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		4.8 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
	15	9.6 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i> , <i>Flavobacterium spp.</i>	Nil		8.9 x 10 ⁴	<i>Aspergillus spp.</i> , <i>Rhizopus spp.</i>
SPA	0	9.2 x 10 ²	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		8.9 x 10 ²	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>
	3	1.1 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		2.2 x 10 ³	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>
	6	7.9 x 10 ³	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		6.2 x 10 ³	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>
	9	3.2 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		1.0 x 10 ⁴	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>
	12	7.0 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		5.5 x 10 ⁴	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>
	15	9.9 x 10 ⁴	<i>Bacillus spp.</i> , <i>Pseudomonas spp.</i>	Nil		9.6 x 10 ⁴	<i>Penicillium spp.</i> , <i>Aspergillus spp.</i>

2 Key

3 TVC: Total Viable Count

4 TCC: Total Coliform Count

5 TFC: Total Fungal Count

ISOLATION AND MOLECULAR IDENTIFICATION OF FUNGI ASSOCIATED WITH FRESH AND SMOKED CATFISH SOLD IN MINNA METROPOLIS, NIGER STATE, NIGERIA

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ABSTRACT

Fish is one of the main sources of food consumed by humans constituting an important part of the diet of many countries. Smoking of fish has been one of the most practiced ways of preserving fish in Nigeria. This study was carried out to determine fungal species present in fresh and smoked catfish (*Clarias gariepinus*) obtained from different markets in Minna metropolis. A total of twenty (20) fish samples were analysed, 10 each for fresh and smoked fish. Mycological examination of the samples were performed using standard microbial protocols. Fungal species were identified based on cultural morphology, microscopic analysis and the 16S rRNA sequencing molecular technique. Results revealed that out of 20 samples assessed, 17 had fungal growth. Fresh fish samples had fungal count of $1-46 \times 10^3$ cfu/g while smoked fish samples had fungal count of $1-3 \times 10^3$ cfu/g. Higher fungal count was observed with fresh fish samples. *Aspergillus fumigatus*, *Trichoderma viride* and *Aspergillus niger* were identified. This suggests that fresh and smoked fish samples in this study were contaminated with fungi and hence effective fish handling and storage techniques should be adopted by fishermen and traders to avoid risk of infection by these organisms.

KEYWORDS: *Clarias gariepinus*, Fungal Contamination, Fresh Fish, Isolation, Smoked Fish.

INTRODUCTION

Fish and fishery products are an important food component for a large part of the world's population, with an average consumption level of 20.1 kg per capita. In tropical regions, conservation of fresh fish remains a problem because of the lack of adequate infrastructures, environmental and climatic conditions that contribute to its spoilage (Anihouvi et al., 2019). Microbial action plays a large role in fish spoilage. Each kind of foods has its natural characteristics such as appearance, texture, smell, taste and flavour, therefore any change in one or more of these characteristics indicates spoilage (Shori, 2017). Following the death of fish, spoilage microorganisms enter the muscle from the skin and gills, disintegrate the muscle cells and take necessary energy to grow. As such, different types of processing and preservation methods have used to keep the freshness and nutritive value of fish flesh in a condition as

near as possible to that of fresh fish (Dutta *et al.*, 2018). Smoking is the most popular method of fish processing (Ayelojaet *al.*, 2018). Smoking gives the product a desirable colour, taste and aroma and a longer shelf-life through its antibacterial and oxidative effect, lowering of pH and acts as antagonist to spoilage (Dutta *et al.*, 2018). This study was aimed at isolating and identifying fungi species associated with fresh and smoked fish sold in Minna, Niger state. The assay of microbial quality is needed to ensure the public health safety of fresh and smoked fish consumed by the public.

MATERIALS AND METHODS

Sample Collection

A total of 20 samples of fresh and smoked fish were collected randomly from five different markets in Minna. At each collection site, 4 samples of both fresh and smoked catfish will be bought. These collection sites included Bosso market, Kure market, Mobil market, Chanchaga market and LapaiGwari market. The collected samples were kept separately in sterile ziploc bags and transported to the Microbiology Laboratory of Federal University of Technology, Minna for analysis.

Media preparation

Sabouraud dextrose agar (SDA) a growth medium used to cultivate various types of fungi species was used in this study. The medium was prepared by dissolving 65g of the Sabouraud dextrose agar powder into 1 litre of distilled water according to manufacturer's instructions. A measurement of 50mg of chloramphenicol antibiotics was added to inhibit the growth of a wide range spectrum of gram-positive and gram-negative bacteria. The mixture is boiled to allow complete dissolution of the powder and then sterilized by autoclaving at 121°C for 15 minutes. The medium is then allowed to cool to around 45°C before usage.

Estimation and Isolation and Fungi species

One gram (1 g) of each fish sample was added into test tubes containing 9mL of sterile water and a serial 10-fold dilution was made to a dilution of 10⁻³. The total fungal count was determined using pour plate technique. One (1mL) of the 10⁻³ dilution of each sample was aseptically transferred into sterile petri dishes and molten Sabouraud dextrose agar medium was poured into respective petri dishes and allowed to solidify before incubating at 25°C for 48-72 hours. This process was carried out in duplicates for each sample. The plates were then screened for the presence of discrete colonies after incubation period and the actual numbers of fungi, mold and yeast were estimated in colony forming unit per gram (cfu/g). Microbial colonies that appear on the plates after incubation were sub-cultured on separate SDA plates to obtain pure cultures which were stored on agar slants for identification and further analysis.

Estimation of the microbial load in sample

The microbial concentration was expressed in colony forming unit (cfu) per gram of sample, which is an estimate of viable fungal cells in a sample. Colony forming unit was calculated using Equation 1:

$$cfu/g = \frac{\text{Number of colonies} \times \text{Dilution factor}}{\text{Volume plated}} \quad (1)$$

Characterization and Identification of microbial Isolates

The routine laboratory method of Cruickshank *et al.* (1975) was used to characterize the different isolates. Fungal isolates were identified based on colony morphology, microscopic analysis and molecular characteristics determined using the 16SrRNA sequencing technique.

RESULTS AND DISCUSSION

Total fungal count of fresh and smoked Catfish samples

Table 1 shows the result obtained from the mycological analysis of fresh and smoked fish samples analysed. Amongst the analysed samples 17 had fungal growth. The total fungal count of fresh fish samples was higher than that of smoked fish. Fresh fish total fungal count ranged from 1- 46x10³cfu/g while that of smoked fish ranged from 1- 3x10³ cfu/g.

TABLE 1: TOTAL FUNGAL COUNTS OF FRESH AND SMOKED FISH SAMPLES.

S/N	sample code	sample location	Fungal count(x10 ³ cfu/g)		
			plate 1	plate 2	average
FRESH FISH					
1	AF	LapaiGwari	6	8	7
2	BF	Mobil	-	-	-
3	CF	Chanchaga	43	49	46
4	DF	KasuwanGwari	8	12	10
5	EF	Kure Market	45	40	43
6	GF	LapaiGwari	1	1	1
7	HF	Mobil	1	2	2
8	IF	Chanchaga	3	11	7
9	JF	KasuwanGwari	13	7	10
10	KF	Kure Market	32	28	30
Smoked Fish					
11	AD	LapaiGwari	1	0	1
12	BD	Mobil	-	-	-
13	CD	Chanchaga	1	2	2

14	DD	KasuwanGwari	2	3	1
15	ED	Kure Market	1	1	1
16	GD	LapaiGwari	0	1	1
17	HD	Mobil	-	-	-
18	ID	Chanchaga	1	2	2
19	JD	KasuwanGwari	3	2	3
20	KD	Kure Market	2	1	2

Keys; F: Fresh fish; D: Smoked fish; -: No growth

Identification of Fungal Isolates

Based on the macroscopic, microscopic and molecular analysis of fungi isolates, three species of fungi were identified. They include *Aspergillus niger*, *Aspergillus fumigatus* and *Trichoderma viride*. The molecular characteristics of these fungal isolates are shown in Table 2

TABLE 2: Molecular identification of Fungal isolates from fresh and smoked catfish

sample ID	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
sample 4	<i>Trichoderma viride</i>	1007	1007	99%	0	99.64%	556	ON755861
sample3	<i>Aspergillus fumigatus</i>	1158	1158	99%	0	100.00%	632	ON755862
sample 9	<i>Aspergillus niger</i>	1029	1029	99%	0	99.47%	576	ON755863
sample 8	<i>Aspergillus fumigatus</i>	1147	1147	99%	0	99.84%	632	ON755864

DISCUSSION

Contamination of fish product with fungal species plays an important role, from economic losses due to the possible spoilage of such food which could be unfit for human consumption or even unmarketable to consumers (Salem-Bekheet *et al.*, 2011). Most of the fish samples analysed from this study were observed to be contaminated with various fungal species with fresh fish samples having higher contamination compared to smoked fish. The maximum fresh fish fungal count recorded was 46×10^3 cfu/g while that of smoked was 3×10^3 cfu/g. The observed higher level of contamination in fresh fish samples could be attributed to its high moisture content, poor storage conditions, improper handling, transportation and selling of fish by vendors. This result was corroborated by Nure *et al.* (2020) who also recorded highest fungal growth in fresh fish compared to dried fish. Three species of fungi were identified in this study with *Aspergillus fumigatus* been the most common followed by *Trichoderma viride* and then *Aspergillus niger*. Similar fungal species were also reported in the study conducted

by Chukwuemeka *et al.* (2020). However, the above mentioned study also reported various other fungal species including *Alternaria* sp., *Cladosporium* sp., *Fusarium* sp., *Mucor* sp., *Rhizopus* sp., *Candida* sp., *Trichophyton* sp., *Saccharomyces* sp., *Penicillium* sp. and various other *Aspergillus* species. The *Aspergillus* species isolated in this study are ubiquitous in nature commonly found in soil and water environments which tend to be in close contact with most vendored fishes as such contamination easily occur due to improper sanitation during catching, improper handling and processing, poor storage and unhygienic post-processing handling, transportation and selling of fish (Chukwuemeka *et al.*, 2020). The growth of any of these fungus species on fish could cause spoilage, discolouration, rotting, alteration of flavour and textural quality of fish which leads to loss of nutrients quality and huge economic loss. In addition, Ibn Abbas *et al.* (2015) stated that the presence of these *Aspergillus* species makes the consumption of such fishes hazardous to humans as these species of organisms have been reported to be mycotoxinogenic producing toxins such as the aflatoxins and ochratoxins which could induce gastrointestinal and metabolic disturbance and other ailments (Sarjito *et al.*, 2019). On the other hand, *Trichoderma viride* was reported by Abdelhamid *et al.* (2009) to be a promising biocontrol agent against fish pathogens and contaminants such as *Aspergillus* species. *Trichoderma viride* are effective bio fungicides, enzymatically degrading other fungi, producing antimicrobial compounds that kill pathogenic fungi promoting the growth of plants therefore, limiting the growth of plant pathogens.

CONCLUSION AND RECOMMENDATION

Molecular identification of fungal isolates from fresh and smoked catfish (*Clarias gariepinus*) validates the presence of *Aspergillus fumigatus*, *Aspergillus niger* and *Trichoderma viride* in the present study. The most abundant fungal species encountered was *Aspergillus fumigatus* (50%) followed by *Trichoderma viride* (30%) and *Aspergillus niger* (20%).

Based on the present study, the following recommendations were made:

There is need to educate fishermen, fish processors and sellers on how to carry out good hygiene practices and to preserve fresh fishes in order to reduce spoilage by pathogenic organisms. Fish should be smoked properly to remove moisture content in order to control the growth and survival of fungi on the fish. Proper cooking of both fresh and smoked fish bought from the market by consumers is essential to reduce the risk of contamination.

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ANTIMICROBIAL ACTIVITY OF *CURCUMA LONGA* ESSENTIAL OIL EXTRACT ON SOME ASSOCIATED FOOD PATHOGENS OF DRIED MEAT (KUNDI)

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Abstract

Dried meat (*kundi*) being a popular and ideal source of high quality animal protein, it is also a viable vehicle for foodborne diseases due to improper handlings. This study investigated the antimicrobial activity, minimum inhibitory, bactericidal and fungicidal concentration (MIC, MBC and MFC) of *Curcuma longa* L. essential oil extract on some associated pathogens of the dried meat (*kundi*). The results of the antibacterial activity to *Curcuma longa* essential oil ranged from 0.00 to 26.00 (100mg/ml), 0.00 to 24.00 (50 mg/ml), 0.00 to 22.00 (25 mg/ml) and 22.00 (12.5 mg/ml). The antifungal susceptibility to *Curcuma longa* essential oil ranged between 0 to 22.50 (100 mg/ml), 0 to 24.00 (50 mg/ml), 0 to 22.00m (25 mg/ml) and 0 to 22.00 (12.5 mg/ml). The result for bactericidal activity of *Curcuma longa* essential oil ranged from 3.125 to 25 mg/ml (MIC), and 6.25 to 50 mg/ml (MBC). The fungicidal property ranged from 3.125 to 25 mg/ml (MIC) and 6.25 to 25 mg/ml. It can be concluded that *Curcuma longa* essential oil exhibited very good inhibitory activity against *Staphylococcus aureus* and *Fusarium oxysporum* among the pathogens and can be used as natural preservative against dried meat spoilage organisms.

Key words: *Curcuma longa*, Safety, Antimicrobial agent, Essential oil, Kundi, Pathogen

Introduction

Essential oils (EOs) are a diverse class of complete and complex combinations of secondary plant metabolites. They are highly concentrated, volatile, oily distillates that are present in all plant parts (flowers, barks, roots, leaves, peels, and seeds) as a result of the action of both endogenous and external secretory plant tissues. EOs could be obtained by hydro-distillation, water/steam distillation, expression and extraction with supercritical carbon dioxide (Tongnuanchan, and Benjakul, 2014). EOs are primarily used as natural preservatives, flavorings, fragrances and full of potentials due to presence of bioactive compounds. EOs from medicinal spices and vegetables are important sources of antimicrobial agents (Mithet *al.*, 2014). The bioactive compounds such as EOs discovered in plant extracts have drawn the attention of food and health related industries including pharmaceutical and food processing industries as replacement of chemical additives or preservatives. *Turmeric* (*Curcuma longa* L.,

Zingiberaceae), among medicinal and aromatic plant species (MAPs) is widely known for its attractive culinary, cosmetic and medicinal functionality (Ibanez and Blazquez, 2021), with distinctive organoleptic properties. The external part being yellow or brown in colour, with a deep orange internal part, special aromatic smell and a bitter, hot taste. These characteristics make *C. longa* rhizome ideal for gastronomy. The essential oil constituent provides the *C. longa* rhizome its peculiar spicy and aromatic flavour with its distinctive chemical composition (Abraham *et al.*, 2018), thus being widely used as a spice, food preservative, and coloring agent. Kundi is a traditional sun-dried or hard-smoked meat mainly sourced from cow or camel; often processed from discarded or rejected animals including donkey, horses, buffalo and elephants, widely embraced and consumed in Africa (Adeyeye, 2016). Over the years, this high-quality nutritious dried meat product received recognition owing to the ancient method of storage and the quest for convenience, accessible and affordable protein among people. Being recognized as a stable product with a shelf life of up to two years, the dried meat product serves as a vehicle for foodborne diseases pathogens, posing staggering threats to public health and food safety issues of high microflora (pathogens) contamination due to poor handling, processing and storage (Oladejo and Adebayo-Tayo, 2011). This study evaluated the effect of *Curcuma longa* essential oil extract as a preservative against common microorganisms (pathogens) associated with dried meat (*kundi*) and the extract concentration suitable for inhibition of the microflora.

Materials and Methods

Preparation of Turmeric (*Curcumin longa*) Powder

Turmeric rhizomes (5kg) were purchased from a farm within Ibadan, Oyo State. The rhizomes were washed with distilled water, peeled, cut into pieces and placed in the oven to dry at temperature of 45°C for 3 days and stored at 4°C prior usage. Extraction of essential oils was carried out according to the method described by Obuotoret *al.* (2017). Seven standard microorganisms were considered to determine the antimicrobial activity of essential oil extracts of Turmeric rhizome following discoveries of Adeyeye (2016). They include *Aspergillus niger*, *Fusarium oxysporum*, *Candida albicans*, *Escherichia coli*, *Bacillus subtilis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

Methodology

Antimicrobial activity

The agar well diffusion method as described by Najah and Neama (2015) was used with slight modifications was used for antibacterial and antifungal activity; and results were expressed in terms of the diameter of the inhibition zone: < 9 mm, inactive; 9-12 mm, partially active; 13-18 mm, active; >18 mm, very active (Najah and Neama, 2015). Four different concentrations of essential oil extract were utilized (100, 50, 25, 12.5 mg/ml).

Minimum Inhibitory Concentration (MIC)

Antibacterial assay was performed using the agar dilution method (Yaouba *et al.*, 2010), in duplicates with slight modifications.

Determination of Minimum Bactericidal Concentration (MBC) and Minimum Fungicidal Concentration (MFC)

The MBC and MFC were determined for all isolates by sub-culturing from all the test mixtures where no visible growth was observed on the MIC plates into 5 mL of sterile nutrient broth (NB) with the aid of cotton swab from surface where no visible growth was observed. The broth media were incubated at 37°C for 24 h and 25°C for 48 h respectively. The MBC and MFC were recorded as the least concentrations where no growth was observed.

Statistical Analysis

Data were subjected to descriptive and Analysis of variance (ANOVA). Duncan Multiple Range Test was used to determine the significant differences among the organisms at $p < 0.05$

Results and Discussion

The essential oil of *Curcuma longa* exhibited good inhibitory activity on the growth of tested pathogens and the results are shown in Table 1. The results of the antibacterial activity to *Curcuma longa* essential oil ranged from 0 to 26.00 (100mg/ml), 0 to 24.00 (50 mg/ml), 0 to 22.00 (25 mg/ml) and 22.00 (12.5 mg/ml). The antifungal activity to *Curcuma longa* essential oil ranged between 0 to 22.50 (100 mg/ml), 0 to 24.00 (50 mg/ml), 0 to 22.00 (25 mg/ml) and 0 to 22.00 (12.5 mg/ml). *Curcuma longa* essential oil exhibited very good inhibitory activity against *Staphylococcus aureus* and *Fusarium oxysporum* among the pathogens. This conforms partly to the findings of Lee *et al.* (2011) which reported high susceptibility of some bacteria strains to *Zanthoxylum piperitum* essential oil. Singh *et al.* (2011) examined the essential oil from the rhizomes of Roma cultivar of turmeric (*Curcuma longa*) from Orissa (India) for its antimicrobial activity against some pathogens and discovered that the oil showed very good activity against the microbial strains such as *Staphylococcus aureus*, *Candida albicans* and *Aspergillus niger*. At concentration of 12.5mg/ml, no zone of inhibition was recorded against *Pseudomonas aeruginosa* and *Aspergillus niger*. This could be attributed to the ineffectiveness of essential oil extract at low concentration of 12.5mg/ml. owing to the physical qualities of essential oils, that is, low molecular weight combined with pronounced lipophilic tendencies allow them to penetrate cell membrane more quickly than other substances; which invariably results to high susceptibility of pathogens.

Table 2 highlights the minimum inhibitory concentration (MIC) and minimum bactericidal and fungicidal concentration (MFC) of *Curcuma longa* essential oil extract against some pathogens. The result for bactericidal property of *Curcuma longa* essential oil ranged between 3.125 to 25 mg/ml (MIC), and 6.25 to 50 mg/ml (MBC). *Staphylococcus aureus* was highly sensitive to *Curcuma longa* essential oil with the lowest minimum inhibitory concentration while *Pseudomonas aeruginosa* had the highest MIC indication of low sensitivity. The fungicidal property ranged from 3.125 to 25 mg/ml (MIC) and 6.25 to 25 mg/ml. *Fusarium oxysporum* had the lowest minimum inhibitory concentration and *Aspergillus niger* among the fungi tested. Meanwhile *Aspergillus niger* organism had the highest value while the rest had similar results of minimum fungicidal concentrations. This shows that *Fusarium oxysporum* was highly susceptible to curcumin essential oil extract, followed by the three fungal pathogens. The actions of essential oil extract against bacteria and fungi may be due to the inhibition of the cell wall

through pore formation in the cell and leakage of cytoplasmic constituents by the bioactive components of the extract, coagulation of the wall proteins, leakage of vital constituents from the cell, inhibition of enzyme activities and disruption of cell wall integrity or microbial membranes (Olajuyigbe and Afolayan, 2012).

Conclusion

The essential oil of *Curcuma longa* exhibited good inhibitory activity on the growth of associated pathogens especially against *Staphylococcus aureus* and *Fusarium oxysporum* among the tested pathogens.

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Table 1: Antibacterial and Antifungal activity of *Curcuma longa* essential oil against common pathogens

Pathogens/ conc(mg/ml)	positive control	negative control	100	50	25	12.5	SEM
Mean Zone of inhibition (mm)							
<i>Staphylococcus aureus</i>	26.000 ^a	0.000 ^e	23.000 ^b	20.500 ^c	16.500 ^d	15.000 ^d	0.645
<i>Bacillus subtilis</i>	20.500 ^a	0.000 ^d	21.000 ^a	17.000 ^b	15.500 ^b	14.500 ^c	0.677
<i>Pseudomonas aeruginosa</i>	23.500 ^a	0.000 ^e	17.000 ^b	14.500 ^c	12.500 ^d	0.000 ^e	0.540
<i>Escherichia coli</i>	23.000 ^a	0.000 ^c	21.000 ^a	17.500 ^b	16.500 ^b	15.000 ^b	0.764
<i>Candida albicans</i>	22.000 ^a	0.000 ^e	17.500 ^b	15.000 ^c	13.500 ^d	12.000 ^d	0.500
<i>Aspergillus niger</i>	22.000 ^a	0.000 ^d	15.000 ^b	12.500 ^c	11.000 ^c	0.000 ^d	0.000
<i>Fusarium oxysporum</i>	24.000 ^a	0.000 ^e	23.000 ^b	20.500 ^b	17.500 ^c	14.500 ^d	0.540

Means in the same column with different superscripts are significantly (P<0.05) different. Positive control for bacteria – Gentamycin (10µg); Positive control for fungi – Ticonazole (1%); Negative control – methanol; SEM –standard error mean

Table 2: Minimum inhibitory, Bactericidal and Fungicidal concentrations of *Curcuma longa* essential oil extract on some pathogens

Extract/Bacteria	<i>Staphylococcus aureus</i>	<i>Bacillus subtilis</i>	<i>Pseudomonas aeruginosa</i>	<i>Escherichia coli</i>
MIC (mg/ml)	3.125	6.25	25	6.25
MBC (mg/ml)	6.25	6.25	50	12.5
Extract/Fungi	<i>Candida albicans</i>	<i>Aspergillus niger</i>	<i>Fusarium oxysporum</i>	
MIC (mg/ml)	6.25	25	3.125	
MFC (mg/ml)	6.25	25	6.25	

MIC: minimum inhibitory concentration; MBC: minimum bactericidal concentration; MFC: minimum fungicidal concentration

MARKET SURVEY, PROXIMATE ANALYSIS AND AFLATOXIN CONTAMINATION LEVEL OF SHELLED OIL SEEDS SOLD AT IDDO GRAIN MARKET, LAGOS.

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Abstract

Two survey visits to assess aflatoxin contamination levels in shelled groundnut *Arachis hypogea* L. and shelled melon *Cucumpropis mannii* N. seeds were made at Iddo market in Lagos in 2017 and 2020. Shelled groundnut and melon samples were randomly purchased from thirty (30) different stalls, collected in ziplock bags and labeled according to their sources. Each sample weighed approximately 800g and 600g respectively.

Proximate and microbial analyses were evaluated to determine the influence of moisture content and presence of molds on the levels of aflatoxins while processing methods on the reduction of aflatoxin levels in the samples were assessed. Enzyme-linked immunosorbent assay (ELISA), RIDA Chromate apparatus was used in determination of aflatoxin levels. The melon and groundnut samples analyzed in this study had fungal loads was 1.0×10^3 and 1.65×10^4 respectively. The unit of the fungal load is cfu/100g. The values 1.0×10^3 and 1.65×10^4 were below the ICSMF official limit which means they did not exceed the standard of 10^5 cfu/g of food and are microbiologically safe for consumption.

The aflatoxin contents of the unprocessed samples of shelled groundnut and melon seeds ranged from 2.9 - 7.3 ppb while that of processed shelled groundnut and melon samples ranged from 2.9 -5.1 ppb. Total aflatoxin contents in unprocessed samples were significantly ($P < 0.05$) higher than the processed oilseeds. Thus, indicating that grain seed processing (washing and drying) significantly decreased ($P < 0.001$) the aflatoxin levels.

Key words: Survey, oilseeds, aflatoxin, ELISA method, microbial quality,

Introduction

Oil seeds are a major food commodity widely cultivated, traded and consumed within Nigeria. To maximize profits, reduce post-harvest losses and extend shelf life, the stakeholders engage in different practices which pose threats to health and wellbeing of consumers. These commodities are improperly handled, heavily treated with synthetic chemicals and transported in the most unhygienic conditions. Oilseeds are also at a high risk of being contaminated with aflatoxins; which are secondary metabolites produced by fungi of the genus *Aspergillus*, predominantly by *A. flavus*, *A. parasiticus* and *A. nomius*, which occur naturally in foodstuffs, leading to a wide variety of toxic effects in vertebrates, including humans. Contamination of food products with aflatoxigenic fungi may occur during production, harvesting, processing, transportation and storage. Human exposure to mycotoxins occurs primarily through the ingestion of contaminated food (Bordin *et. al.*, 2004). The need to analyse the proximate and microbial contents on the oilseed samples in order to determine the influence of moisture content and presence of molds on aflatoxin levels and assess the influence of processing methods (washing and drying) on the reduction of aflatoxin levels present in shelled groundnut and shelled melon seeds sold in Iddo market in Lagos metropolis necessitated the institute to carry out these surveys.

Materials and Methods

Market Survey

Market surveys were made to grain market at Iddo, Lagos because of the large aggregation of traders, varieties of commodities sold, prior engagements with the trading unions and access from the Lagos Zonal Office. Common practices of traders were assessed and recorded from when the bulk grains were offloaded from transport vehicles that brought them from the “north” according to the traders. Packing, storage and distribution for either retail or wholesale purposes were observed and documented.

Sampling for Analysis

Shelled groundnut and melon samples were randomly purchased from thirty (30) different stalls, collected in zip lock bags and labeled according to their sources. Each sample weighed approximately 800g and 600g respectively. The samples were transported carefully to the Food Processing Centre of the NSPRI Zonal Office, Lagos where they were cleaned, damaged seeds and extraneous materials handpicked and sieved.

The sorted, clean picked samples were weighed at 300g each and packed in tightly packed foil paper and then in translucent big brown envelopes. The discolored and damaged seeds were weighed and also stored away. The packed clean samples were labeled according to seed type and source and stored together in big airtight polythene bags and then in polypropylene sacks and then in plastic drums, with tightening clamps to cut off inflow of air. The wholesome shelled groundnut was bulked and mixed thoroughly in order to obtain a homogenous

mixture. Similar method was applied to the shelled melon. The conning and quartering method was employed in order to get an appropriate representative sample of each 300g groundnut or melon for analyses.

The representative samples of each groundnut and melon were subjected to proximate analysis determined according to the standard analytical method by the Association of Official Analytic Chemist (AOAC, 2005), microbial count was determined using the method of (Schlegelova, *et al*; 2010).

Sample Preparation for aflatoxin

30g representative sample of each groundnut and melon grains were washed, sun-dried and then further dried in the NSPRI Multi-crop dryer and 10g taken labeled processed groundnut and melon separately.

In the Biochemistry laboratory 10g of the representative sample of each unprocessed groundnut and melon were milled and extraction method according to Atehnkeng, *et al.*, (2008) was followed and homogenization followed according to standard procedures.

Total Aflatoxin Content Determination

Assay procedure was followed according to the protocol provided by RIDASCREEN® Aflatoxin Total (ART. No. R4701, R-Biopharm AG, Darmstadt, Germany).

All analysis in duplicates. Standard solutions were prepared for Total aflatoxin calibration curves. The lower concentrations were 0.05ppb, whereas the higher concentrations were 4.05ppb. Samples that were beyond the range of the highest standard concentration were diluted, and the ELISA experiments were repeated. The Total aflatoxins content of each sample was calculated using the prepared standard curve.

Total Aflatoxin Validation

The validation of ELISA methods was carried out with the determination of the recoveries and the coefficient of variation (%CV). A specific software, the RIDA® SOFT Win.net (ART No. Z9996) evaluated and analyzed the total Aflatoxin data.

Statistical Analysis

The data obtained for proximate composition of the oil seeds were determined in duplicates for central tendencies (mean) and expressed as mean $\pm$ standard deviation of the observations. T-test excel formula was used to ascertain significant differences ($P < 0.05$) in the parameters between the oil seeds.

Results

Origin of melon purchased is predominantly from Delta State and so the traders regard the melon as “Asaba”. Groundnut varieties were from two states; Adamawa and Niger.

The result of proximate content showed moisture content of 4.13% and 7.48% for groundnut and melon respectively. The carbohydrate content of the analyzed groundnut sample (30.2%) and the melon (18.9%). The crude protein for groundnut 18.3% and melon (32.1%). The result of the crude fat content obtained in this study, showed that the groundnut had (28.1%) while the melon had a higher crude fat (38.1%) as shown in Table 1. The values (18.3%) and (28.1%) of the groundnut in this study were different to the report on 29.11% and 40.2% for protein

and crude fat respectively by (Ekhuemelo and Abu, 2018). The crude fibre content of groundnut was 15.27% and 5.02% for melon.

The result of shelled groundnut and melon samples analyzed in this study as shown on Table 1 had fungal loads that were below the ICSMF official limit which means they did not exceed the standard of 10^5 cfu/g of food and are microbiologically safe for consumption.

Aflatoxin contents of the unprocessed samples of shelled groundnut and melon ranged from 2.9 - 7.3 ppb as shown in Table 2. While that of processed groundnut and melon ranged from 2.9 - 5.1 ppb. Total Aflatoxin contents in unprocessed samples were higher than in the corresponding processed whole oil seeds. Washing and drying the oil seeds significantly decreased ($P < 0.001$) aflatoxin levels from between 2.9 - 7.3 to between 2.9 - 5.1 ppb, European Union (EU) has the strictest standards, such that any products for direct human consumption can only be marketed with the maximum permissible level for total aflatoxins concentration in unprocessed foods as <4 ppb and for processed food as <2 ppb (European Commission-EC, 2007; 2010). Therefore, the Total aflatoxin content of both the unprocessed and processed oil seeds in this study were above the permissible limits set by EU for consumption.

Table 1: Proximate Composition with T-test and Microbial Profile of Shelled Melon and Groundnut

Proximate Composition			Paired Sample T-test		Microbial Analysis		
Parameters (g/100g)	Melon	Groundnut	t	Sig. (2-tailed)	Parameters	Colony count (Melon)	Colony count (Groundnut)
Carbohydrate	18.94±0.95	30.15±0.01	-16.49	0.04*	Yeast	2.0 x 10 ⁴	ND
Protein	32.1±0.49	33.28±0.01	-3.54	0.18	Mold	1.0 x10 ³	1.65x10 ⁴
Crude Fat	38.05±0.32	28.05±0.38	20.19	0.03*	Mold		Yeast
Moisture Content	7.48±0.47	4.13±0.01	10.47	0.06	Official Limit (ICMSF)	NMT 10 ⁵	NMT 10 ⁶
Ash	1.07±0.11	1.03±0.01	0.57	0.67			
Crude Fibre	2.38±0.21	3.37±0.43	-2.20	0.27	Fungi Morphology	<i>Aspergillus</i> sp. /ND (mold) /(yeast)	<i>Aspergillus</i> sp./ <i>Acremonium</i> sp. (mold) /(yeast)

**** Values for proximate are means of duplicate determinations ± the respective standard deviations.**

**** ICMSF – International Commission on Microbiological Specification for Food**

**** ND – Not detected**

*** - Significant difference (p<0.05)**

The melon and groundnut samples analyzed in this study had fungal loads that were below the ICSMF official limit which means they did not exceed the standard of 10^5 cfu/g of food and are microbiologically safe for consumption.

Table 2. Showing the result of the Aflatoxin samples

<i>Serial No</i>	<i>Standard Concentration (ppb)</i>	<i>Absorbance</i>			<i>Calculated (ppb)</i>	<i>Dilution Factor</i>	<i>Final Calculated (ppb)</i>
		Mean	CV	%			
5.	Unprocessed Melon	2.943	1.2	92.1	0.21	35.00	7.3
6.	Processed Melon	2.956	2.6	92.5	0.15	35.00	5.1
7.	Unprocessed Groundnut	3.023	2.7	94.6	0.082	35.00	2.9
8.	Processed Groundnut	2.986	3.1	93.4	0.11	35.00	3.7

Conclusion

From the study, processing of shelled groundnut and melon seeds by washing and drying before use for consumption reduced the aflatoxin levels though the values were slightly above the permissible limits set by EU for consumption. This requires urgent need for surveillance, detection and analysis of aflatoxins in our agricultural produce along the value food chain before getting to markets by the Institute which main mandate is on postharvest of agricultural produce.

Also, there is need for regular surveys, for update on information for database to both researchers and government in policy decision making by the Institute.

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SHELF LIFE AND MICROBIAL SPOILAGE OF FRESH TOMATOES (*LYCOPERSICON ESCULENTUM*) STORED UNDER FABRICATED EVAPORATIVE COOLING, REFRIGERATION AND AMBIENT SYSTEMS

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Abstract

Tomato (*Lycopersicon esculentum*) contains higher amounts of lycopene, a type of carotenoid with antioxidant properties which is beneficial in reducing the incidence of some chronic diseases like cancer and many other cardiovascular disorders². Postharvest losses in tomatoes could be as high as 25–42% globally³. In developing countries, post harvest deterioration of tomatoes are often more severe due to inadequate storage and transportation facilities. Microbial fruits infection may occur during the growth season, harvesting, handling, transport and post harvest storage and marketing conditions, or after purchasing by the consumer. Therefore, early intervention measures during crop development and harvesting through the use of Good Agricultural Practices (GAP) will provide dramatic reductions in the yield loss due to deterioration at all subsequent steps in the food-to- fork continuum¹. The need for microbiological examination of tomatoes is important as it contributes to a large extent to economic development. Therefore, it becomes quite pertinent to understudy the major spoilage organisms in tomatoes under different storage conditions with a view to ameliorating spoilage and wastage of the fruits. The aim of this study therefore, is to determine the storage life and the micro flora responsible for spoilage of tomatoes stored under different storage conditions.

Materials and Methods

Material Collection and Production Method

The raw material for this study, which is tomatoes, was sourced from the University of Ibadan Teaching and Research farm. The tomato fruits, F1 cobra 26, which is a hybrid tomato variety, were harvested freshly and directly from the plant each time.

The harvested samples were placed in a brown paper envelope for 5 days to attain full red ripeness stage of maturity. The samples were then divided into three portions and placed in the three different storage conditions, viz:- ambient, refrigeration and evaporative cooler system (ECS). The samples were stored unpackaged in the different storage conditions. Some chemical and physicochemical analyses were carried out on the samples initially before placing under the storage conditions.

Experimental Design

A one-way analysis in completely randomized design (CRD) was employed for this work. The tomato samples were placed under the three storage conditions. The samples were monitored and analyzed at 5-day intervals for a period of 20 days. The above mentioned analyses were carried out after every five (5) days and the results recorded. Environmental conditions of temperature and relative humidity were also monitored using Acu Rite weather forecaster model 02001A2 for the refrigeration, ambient and evaporative cooling systems. Weight changes in tomatoes during the storage period were determined using a digital scale. This was done at 5-day intervals for a period of twenty (20) days. Cooling of the storage chamber was provided by the means of riverbed sand which was wetted on a daily basis. Storage under refrigeration was carried out using LG refrigerator model GC-051SA16SNR036 at a temperature of $10 \pm 2^{\circ}\text{C}$.

RESULTS AND DISCUSSION

Temperature and Relative humidity

These are among the major physical factors that influence spoilage of food products under storage. According to ⁴, there is likelihood of spoilage at any temperature between -5 and 70°C . However, this will also depend on the prevailing relative humidity of the storage environment. The prevailing temperatures during storage of samples were 10 ± 2 , 29 ± 2 and $25 \pm 2^{\circ}\text{C}$ for refrigeration, ambient and evaporative cooling systems respectively while their relative humidity were 63%, 67%, and 80% respectively.

Weight changes

The result of weight changes in tomato samples during storage is shown in Table 1. The results show that samples stored under evaporative cooling system has a weight reduction of 3.20 g at the end of storage period which represent a percentage loss of 2.53 %. Samples stored under ambient conditions had a weight reduction of 9.50 g and represents a percentage loss of 9.98 % while those stored under the refrigeration system had a weight reduction of 20.10 g representing a percentage loss of 19.14 %. The higher percentage loss in samples stored under refrigeration could be attributed to the effects of chilling injury as noted by ⁵ which led to oozing out of juice from tomato tissues, while those stored under the refrigeration system had a weight reduction of 20.10 g representing a percentage loss of 19.14 %. The higher percentage

loss in samples stored under refrigeration could be attributed to the effects of chilling injury as noted by ⁵ which led to oozing out of juice from tomato tissues.

Table 1: Weight changes in stored tomato samples during the storage period

Storage period (days)	REF	AMB	ECS
0	105.0g	95.2g	126.3g
5	104.3g	92.3g	125.3g
10	104.3g	90.3g	124.5g
15	103.0g	88.0g	123.7g
20	84.9g	85.7g	123.1g

KEY: ECS (Evaporative cooling system), AMB (Ambient), REF (Refrigeration).

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MICROBIAL INTERVENTIONS IN BIOREMEDIATION OF HYDROCARBON CONTAMINATED SOIL TO FACILITATE YIELD IMPROVEMENT IN COWPEA (*VIGNIA UNGUICULATA*)

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Abstract

Exploration of microorganisms to eradicate or neutralize pollutants such as hydrocarbons from a contaminated site has begins to gain worldwide interest. Research based evidence suggests that potentials of Palm oil mill effluents (POME) degrading microorganisms remain a clear intervention in bioremediation. In this research work, we aimed to utilize POME-degrading microorganisms to bioremediate hydrocarbon-polluted soil while using *Vignia unguiculata* as an experimental plant. Bacterial isolates were screened for hydrocarbon degrading potentials through standard bacteriological techniques, prior to pre-treatment and post-treatment of soil with crude oil. Experimental set up was monitored for 28 days. Of all the bacteria isolates from the POME polluted soil, *K. edwardsii* (18.03), *Bacillus kaustophilus* (16.42), *K. pneumoniae* (16.02) and *Proteus rettgeri* (14.99) performed at optimal levels in terms of Shoot heights. Similarly, observation of the results showed that plant grown on contaminated soil treated with *K. edwardsii* had an excellent vegetative yield compared to other tested isolates. Microbial interventions provide an effective and promising way in bioremediation to facilitate yield improvement.

Keyword: Bioremediation, Palm oil mill effluents (POME), Pollution, *Vignia unguiculata*, Yield improvement

Introduction

Pollution in the environment can either be caused by inorganic or organic pollutant; hence, the environmental pollutant of interest by crude oil is relatively common because of its use and its associated disposal operations and accidental spills (Chikere, Okpowasii and Chiker, 2009). Crude oil and its derivatives constitute pollution in soil and water during refining, storage and transportation (Chioma and Chioma, 2014). In recent years, many ecologists have discovered various microbial species that can effectively degrade hydrocarbons in natural environments. Hydrocarbon biodegradation and its level of persistence in the environment are influenced by different factors which include the presence of viable microbial biomass that are capable of degrading the hydrocarbon pollutants, hydrocarbon chemical structures and the optimal environmental conditions that can support the activities of microbial degradation (Chioma and Chioma, 2014). Bioremediation is a modern method in which the natural ability of microorganisms is employed for the reduction of the volume and/or toxicity of various chemical substances, such as petroleum derivatives, aliphatic and aromatic hydrocarbons, industrial solvents, pesticides and metals (Farag and Soliman, 2011).

One of the major environmental problems today is hydrocarbon contamination resulting from the continual activities related to petrochemical industry. However, accidental release of these petroleum products is of a particular concern in the environment because of the detrimental effect they pose on surrounding ecosystem.

Therefore, since both mechanical and chemical methods generally used to remove hydrocarbons from hydrocarbons-polluted sites have limited effectiveness and can be expensive, thus, bioremediation remains the promising technology for the treatment of those contaminants because of its cost effectiveness and complete mineralization. The aim of this research work seeks to utilize POME-degrading bacterial to bioremediate hydrocarbon contaminated soil for yield improvement in *Vigna unguiculata*.

Material and Methods

Sample Collection

The Palm Oil Mill Effluent (POME)-polluted soil was dug with hand trowel between the depths of 5-10 cm and was collected into sterile polythene bags and was transported to the Microbiology Laboratory of the Pure and Applied Biology Department, Ladok Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria. Samples were stored at 4°C as described by (Ibeet *al.*, 2014)

Enrichment, isolation and characterization of hydrocarbon degrading bacteria

Hydrocarbon degrading bacteria was isolated in Minimal Salt (MS) media where crude oil was used as the sole carbon source using standard procedure with some modifications (Ekramet *al.*, 2020). Obtained enrichment culture was spread on Mannitol Salt agar solidified plate and the morphologically distinct colonies were identified. The distinct colonies were further sub-cultured in MS media and finally considered as a pure culture. To characterize the isolated oil degrading bacteria, morphological and biochemical characterization was carried out according to Bergey's Manual of Systematic Bacteriology (Holt *et al.*, 1994).

Experimental Set-Ups for Pre-Treatment and Post-Treatment Field Work

The experimental soil of 2 kg in the 24 plastic buckets were artificially polluted with different crude oil volume ranging from 5 mL, 10 mL, 15 mL, 20 mL and 25 mL. The soil samples were mixed manually with different volume of crude oil and the experiment was set up in 2 replicates at different volumes of crude oil. In order to examine the effect of the activity of micro-organisms on the polluted soil, 250 mL of already screened hydrocarbon degrading bacteria biomass culture containing 10^8 bacteria cells were added into the polluted soil bucket and was thoroughly mixed for even treatment. The processes were carried out for *Klebsiella edwardsii*, *Proteus rettgeri*, *Klebsiella pneumoniae*, and *Bacillus kaustophilus* and the treatment was left for 7 days, all as a standalone microbial experiment. Another bucket containing the experimental soil was polluted with 25 mL of crude oil which represent control 1 and control 2 was the experimental soil without the crude oil. After seven (7) days, three (3) viable seeds of *Vigna unguiculata* were planted into each of the pre-treated buckets and were placed inside the screen boxes for proper monitoring (Alfreda and Ekene, 2012). The experimental buckets were exposed to a mild sunlight inside screen boxes and regular watering was done to maintain the soil moisture content in the absence of rainfall.

Similarly, the experimental 24 plastic buckets containing 2 kg of experimental soil was artificially sprayed with varying volumes of crude oil from 5 mL, 10 mL, 15 mL, 20 mL and 25 mL. The polluted soil samples were mixed manually and the experiment was set up in 2 replicates and was exposed for seven (7) days to a mild sunlight. After the seventh (7th) day, each of the labeled experimental set up was treated with 250 mL inoculums build-up of the microbial biomass for *Klebsiellaedwardsii*, *Proteus rettgeri*, *Klebsiellapneumoniae*, and *Bacillus kaustophilus*, respectively and were properly mixed. The planting of three (3) viable seeds of *Vigniaunquiculata* was carried out immediately after treating the soil. The buckets were exposed to a mild sunlight inside screen boxes and regular watering was done to maintain the soil moisture content in the absence of rainfall (Alfreda and Ekene, 2012). Daily watering, monitoring and observations for 28 days was done on the test plant *Vigniaunquiculata* (Cowpea) for the following vegetative parameters: germination count, shoot height, leaf number, stem width, leaf width for crude oil polluted soil treated with each of the following bacterial isolates: *Klebsiellaedwardsii*, *Proteus rettgeri*, *Klebsiellapneumoniae* and *Bacillus kaustophilus* according to (Alfreda and Ekene, 2012).

Result,

Discussion

The results shown in Figure 1, Table 1 and Table 2 have demonstrated that POME polluted soils harbor a lot of hydrocarbons degrading bacterial, similarly, their ability to degrade POME could serve as an intervention in bioremediation since changes in soil physico-chemical parameters and microbial communities across space are often strongly correlated with differences in the types of microbial strains colonizing the soil coupled with the duration of time spent in exercising their effect. Present study corroborated with the previous study as indicated by (Jenkins 2009; Lauber 2009 and Nilsson 2007). Shoot height observation showed a significant dependency on crude oil volume when the soil was pre-treated, however no significant dependency was observed when post treated ($p < 0.05$). Conclusively, the results of this study show that crude oil (hydrocarbons) can affect different parts of the plants in different ways, but yet some vegetative properties are more sensitive to crude oil pollution as found in the case of non-significant dependency that exist between the germination count and germination period for both pre-treated and post-treated soil, it was observed that the efficacy of the bioremediation process was not affected by the germination period as revealed in vegetative properties, this result was in contrast with the previous study of (Adenipekun, Oyetunji and Kassim, 2008).

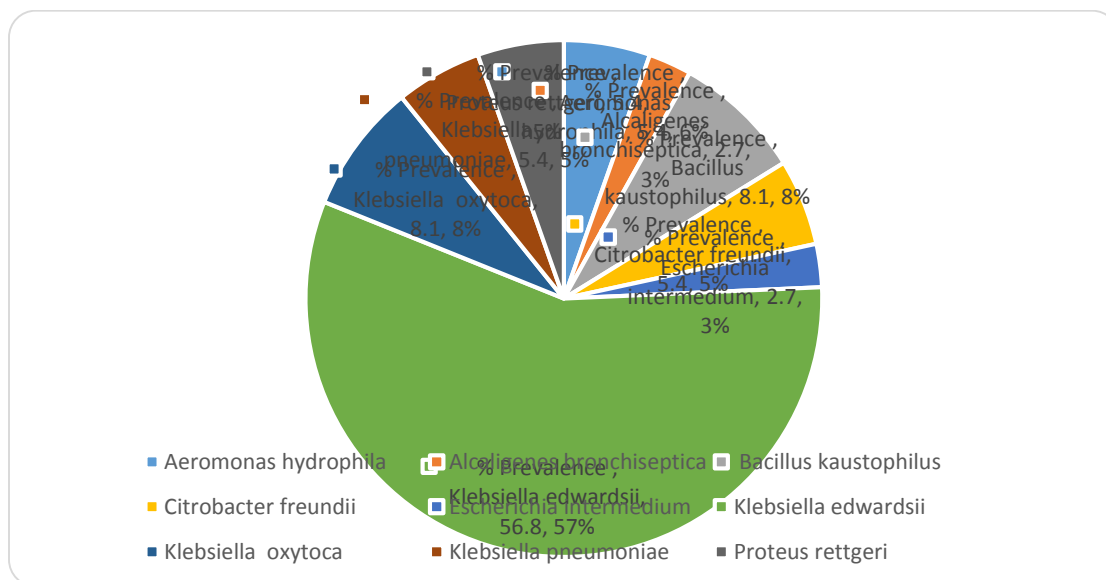


Figure 1: Percentage Prevalence of Bacteria Isolated from POME-Polluted Soil

Further studies can be carried out on the more resistant accessions to determine their suitability for remediation of crude oil contaminated sites. Therefore, the discharge of hydrocarbon compounds in soils should be prohibited because of their adverse effect on growth and development of plants.

Conclusion

In conclusion, the present study has ascertained Palm Oil Mill Effluent (POME) as a reservoir of hydrocarbon bio-degraders which can be utilized in remediation technologies and that the microbial remediation of polluted soil is achievable at a short time line.

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Table 1: Effects of crude-oil volume on different plant parameters

CRUDE OIL VOL. (mL)	GERMINATION COUNT		SHOOT HEIGHT (cm)		LEAF NUMBER		STEM WIDTH (cm)		LEAF WIDTH (cm)	
	PRT	POT	PRT	POT	PRT	POT	PRT	POT	PRT	POT
25	2.13 ^{ab} ±0.11	2.34 ^a ±0.12	12.29 ^a ±1.27	17.73 ^{ab} ±1.38	11.08 ^a ±1.36	17.28 ^a ±2.02	3.70 ^b ±1.44	1.13 ^{ab} ±0.05	4.65 ^a ±0.76	6.65 ^{ab} ±0.43
20	2.38 ^b ±0.09	2.44 ^a ±0.13	17.27 ^b ±0.92	18.78 ^{ab} ±1.17	16.78 ^{ab} ±1.75	20.50 ^{ab} ±2.36	1.19 ^{ab} ±0.05	1.22 ^{ab} ±0.05	6.23 ^{ab} ±0.16	7.47 ^b ±0.24
15	1.84 ^a ±0.19	2.63 ^{ab} ±0.09	14.66 ^{ab} ±1.49	19.75 ^{ab} ±1.37	11.84 ^a ±1.76	21.25 ^{ab} ±2.14	1.01 ^a ±0.09	1.24 ^{ab} ±0.05	5.33 ^{ab} ±0.45	7.02 ^{ab} ±0.28
10	2.28 ^{ab} ±0.14	2.91 ^b ±0.05	18.74 ^b ±1.16	21.93 ^b ±1.28	16.25 ^{ab} ±1.64	26.09 ^b ±2.52	1.20 ^{ab} ±0.04	1.33 ^b ±0.05	6.43 ^b ±0.17	7.92 ^b ±0.24
5	2.50 ^b ±0.13	2.41 ^a ±0.17	18.85 ^b ±1.02	16.13 ^a ±1.46	18.66 ^b ±1.87	15.97 ^a ±1.85	1.24 ^{ab} ±0.03	1.07 ^a ±0.08	6.64 ^b ±0.18	5.93 ^a ±0.45
Crude oil + Soil	2.00±0.38		14.90±1.91		14.50±4.90		0.84±0.09		5.51±0.44	
Soil only	2.13±0.13		23.53±2.88		20.13±4.36		1.59±0.14		7.20±0.74	

Means within the same column with different superscripts are significantly different ($p < 0.05$);

Means within the same column with different superscripts are significantly different ($p < 0.05$);

Table 1 Key:

PRT – Pre-treatment, POT – Post-treatment.

Decisions for pre-treatment analysis when crude oil volume is a factor.

Crude oil volume and germination count are independent on each other ($p = 0.14 > \alpha = 0.05$).

Crude oil volume and the shoot height are dependent on each other ($p = 0.00 < \alpha = 0.05$).

Crude oil volume and leaf number are both dependent on each other ($p = 0.08 < \alpha = 0.05$).

Crude oil volume and stem width are both dependent on each other ($p = 0.02 < \alpha = 0.05$).

Crude oil volume and leaf width are both dependent on each other ($p = 0.00 < \alpha = 0.05$).

Decisions for post-treatment when crude oil volume is a factor.

Crude oil volume and germination count are independent on each other ($p = 0.12 > \alpha = 0.05$).

Crude oil volume and the shoot height are independent on each other ($p = 0.99 > \alpha = 0.05$).

Crude oil volume and leaf number are independent on each other ($p = 0.68 > \alpha = 0.05$).

Crude oil volume and stem width are independent on each other ($p = 0.37 > \alpha = 0.05$).
 Crude oil volume and leaf width are independent on each other ($p = 0.06 > \alpha = 0.05$).

Table 2: Effects of biodegradative activity of microorganisms on different plant parameters

ISOLATE ID	GERMINATION COUNT		SHOOT HEIGHT (cm)		LEAF NUMBER		STEM WIDTH (cm)		LEAF WIDTH (cm)	
	PRT	POT	PRT	POT	PRT	POT	PRT	POT	PRT	POT
K.E	1.90 ^a ±0.09	2.58 ^{ab} ±0.08	18.03 ^a ±0.81	19.85 ^a ±1.04	11.70 ^a ±1.18	19.35 ^a ±1.73	1.40 ^a ±0.46	0.92 ^a ±0.04	6.61 ^a ±0.50	7.52 ^a ±0.25
P.R	2.40 ^b ±0.11	2.25 ^a ±0.15	16.02 ^a ±1.04	16.48 ^a ±1.47	16.44 ^a ±1.48	17.30 ^a ±2.08	1.43 ^a ±0.25	1.09 ^b ±0.06	5.81 ^a ±0.35	6.11 ^a ±0.48
K.P	2.15 ^{ab} ±0.16	2.58 ^{ab} ±0.08	14.99 ^a ±1.34	18.53 ^a ±1.09	15.46 ^a ±1.85	21.90 ^a ±2.01	2.08 ^a ±0.98	1.38 ^a ±0.02	5.27 ^a ±0.37	7.21 ^{ab} ±0.23
B.K	2.45 ^b ±0.75	2.78 ^b ±0.10	16.42 ^a ±1.22	20.60 ^a ±1.17	16.09 ^a ±1.60	22.33 ^a ±2.18	1.76 ^a ±0.44	1.40 ^a ±0.02	5.73 ^a ±0.27	7.15 ^{ab} ±0.21
Crude oil + Soil	2.00±0.38		14.90±1.91		14.50±4.90		0.84±0.09		5.51±0.44	
Soil only	user, 1/1/2006 1:43:00 AM formatted: Width: 8.5", Height: 11"		23.53±2.88		20.13±4.36		1.59±0.14		7.20±0.74	

Means within the same column with different superscripts are significantly different ($p < 0.05$);

Table 2 Key:

PRT – Pre-treatment, POT – Post-treatment, K.e- *Klebsiella edwardsii*, P.r- *Proteus rettgeri*, K.p- *Klebsiella pneumoniae*, B.k- *Bacillus kaustophilus*.

Decisions for pre-treatment analysis when organisms used are factor.

The organisms used and germination count are dependent on each other ($p = 0.01 < \alpha = 0.05$).
 The organisms used and the shoot height are independent on each other ($p = 0.24 > \alpha = 0.05$).
 The organisms used and leaf number are both independent on each other ($p = 0.08 > \alpha = 0.05$).
 The organisms used and stem width are independent on each other ($p = 0.52 > \alpha = 0.05$).
 The organisms used and leaf width relationship are independent on each other ($p = 0.06 > \alpha = 0.05$).

Decisions for post-treatment when organisms used are factor.

The organisms used and germination count are independent on each other ($p = 0.12 > \alpha = 0.05$).
 The organisms used and the shoot height are independent on each other ($p = 0.99 > \alpha = 0.05$).
 The organisms used and leaf number are both independent on each other ($p = 0.68 > \alpha = 0.05$).
 The organisms used and stem width are independent on each other ($p = 0.96 > \alpha = 0.05$).
 The organisms used and leaf width relationship are independent on each other ($p = 0.37 > \alpha = 0.05$).

MINERAL AND ANTI-NUTRITIONAL PROFILE OF GROUNDNUT SHELL FERMENTED WITH *TRICHODERMA SPP.*

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Abstract

This study was undertaken to investigate the effects of fermentation using *Trichoderma spp.* on the mineral and anti-nutritional contents of groundnut shell (*Arachis hypogaea* Linn). Groundnut shells were fermented (solid state fermentation) with *Trichoderma spp.* for 8 days, and oven dried. Samples were subjected to mineral and anti-nutritional analyses. Fermentation significantly ($p < 0.05$) improved phosphorus (485mg/100g), manganese (2.15mg/100g), iron (9.17mg/100g) and sodium (279.90mg/100g) of groundnut shell. Flavonoids, glycosides and alkaloids decreased significantly ($p < 0.05$) while tannin, oxalate and saponins were not significantly different ($p > 0.05$) after fermentation. The results indicate the potential utilization of fermented groundnut shell as a source of minerals in livestock feed.

Keywords: Groundnut shell, *Trichoderma spp.*, Fermentation and Anti-nutritional factors.

Introduction

The outer layer of groundnut is called groundnut shell: The shell constitutes about 25-35% of the pod. Nigeria is the largest groundnut producing country in West Africa, accounting for 51% of production in the region, 39% to that of Africa and contributing about 10% of total global production (Sogut *et al.*, 2016). Increased groundnut production and processing leads to the accumulation of groundnut shells which are either burnt or buried. As groundnut shells are rich in many functional compounds and composed of cellulose, hemicellulose and lignin, they can be utilized in multiple ways. An efficient management strategy is required to convert this otherwise considered waste into valuable bio-products to achieve zero waste production system. Filamentous fungi are one of the major sources of cellulases and hemicellulases. Among prominent fungi, *Aspergillus* and *Trichoderma* have been widely exploited (Treebupachatsakul *et al.*, 2016). *Trichoderma* strains have been reported to produce high activities of both CMCase and exo-glucanase but have poor release of β -glucosidase, which causes accumulation of cellobiose. The current study was carried out to evaluate the effect of fermentation with *Trichoderma spp.* on the minerals and the anti-nutritional content of groundnut shells.

Materials and Methods

Substrate preparation

Groundnut shells were collected from groundnut processing area in New Bussa, Borgu L. G. A., Niger State and sun dried (39⁰C) for 3 days. Dried groundnut shells were milled and sieved with standard 0.5mm mesh to obtain the desired particle size. The sample was packed in a polythene bag and stored at -20 ⁰C until used.

Fermentation protocol

Solid state fermentation was carried out according to the method of Saxena and Singh, (2011) with some modifications. Fifty grams (50 g) of substrate (Groundnut shell powder) was added to 250ml Erlenmeyer flasks, moistened with 30 ml of sterile distilled water, and autoclaved at 121⁰C at 15 psi for 15 mins. Each flask was then inoculated with 10 ml *Trichoderma spp.* culture. Fermentation was carried out at ambient temperature (28 ± 2 ⁰C) for 8 days under static condition (without agitation). The fermented mass was oven-dried at 60⁰C for 8h and packaged in labeled polythene bag.

Chemical Analysis

Mineral contents (calcium, magnesium, sodium, potassium, iron copper, zinc and manganese) were determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Anti-nutritional factors such as saponin, tannins, oxalate, flavonoids, glycosides and alkaloids were determined according to standard procedures.

Statistical analysis

The results were subjected to independent t – test for significant difference (p<0.5) using Statistical package for social sciences (SPSS) version 20.0 (IBM SPSS).

Results and Discussion

Table 1 shows the mineral content of fermented and unfermented groundnut shell. Minerals are important in animal nutrition. Fermented groundnut shells showed higher concentration of minerals compared to unfermented sample, except Magnesium. The higher mineral content of the treated samples agrees with the report of Adu (2009) who reported 168.3% increase in calcium, 340.23% increase in potassium and 46.3% increase in phosphorus when cassava peels were fermented with *Pleurotus ostreatus*. Similar observations were made in study conducted by Belewu and Babalola (2009) when agricultural residues were fermented with *Rhizopus oligosporus*. The increases observed might be partly due to mineral accumulation from *Trichoderma spp.* Fungi enhance phyto-accumulation of minerals (Jacqueline and Broerse, 1996). Since these minerals are required for growth, there is no doubt that their enhancement by the *Trichoderma spp.* will go a long way to tremendously improve the health of animals when they feed on the fermented materials.

Table 1: Mineral profile (mg/100g) of fermented and unfermented groundnut shells

	Magnesium	Phosphorus	Manganese	Calcium	Iron	Sodium	Copper
A	219.21±0.00 ^b (-9%)	485.00±0.00 ^a (+27%)	2.15±0.00 ^a (+67%)	295.41±0.00 ^a (+1%)	9.17±0.37 ^a (+145%)	279.90±7.55 ^a (+143%)	0.421±0.00 ^a (+86%)
B	239.57±0.15 ^a	381.67±5.77 ^b	1.29±0.00 ^b	292.15±0.00 ^b	3.75±0.36 ^b	115.120±9.89 ^b	0.360±0.00 ^b

Values are means with standard deviations. Values with different superscript letters in a column vary significant at P<0.05 Sample A= Fermented groundnut shell; Sample B= unfermented groundnut shell

Fermentation induced appreciable decrease in some of the anti-nutritional factors of the groundnut shells. However, the values of anti-nutrients recorded were below the minimum threshold index level of 1.5 of good quality protein. Groundnut shells when fermented can therefore serve as a valuable source of minerals (such as phosphorus, calcium, iron e.t.c.) in livestock feed.

Conclusion

Groundnut shell contain appreciable amount of mineral elements which increased significantly after fermentation. It also contains acceptable levels of antinutrients.

Table 2: Anti-nutrients composition (mg/100g) of fermented and unfermented groundnut shells

	Flavonoid	Tannin	Oxalate	Glycosides	Saponin	Alkaloids
A	0.778±0.01 ^b (-25%)	0.516±0.01 ^a (-4%)	0.452±0.01 ^a (-4%)	0.161±0.03 ^b (-10%)	0.311±0.01 ^a (-10%)	0.94±0.04 ^b (-16%)
B	1.042±0.02 ^a	0.536±0.02 ^a	0.470±0.02 ^a	0.174±0.02 ^a	0.344±0.01 ^a	1.119±0.01 ^a

Mean ± standard deviation value with different superscript letters in a column vary significant at P<0.05. Sample A= Fermented groundnut shell; Sample B= unfermented groundnut shell

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MICROBIOLOGICAL CHARACTERISTICS OF NON-EVISCERATED SMOKED BLUE WHITING (*MICROMESISTIUS POUTASSOU*) FISH DURING STORAGE

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Abstract

The safety of the traditionally smoked fish is becoming a major public health concern. This study investigated the microbial qualities of non-eviscerated smoked Blue Whiting fish (*Micromesistius poutassou*) during storage. Non-eviscerated market and control (laboratory prepared eviscerated (EVS) and non-eviscerated smoked fish (NEVS)) samples were analysed for microbial qualities: [total plate count (TPC), total fungal count (TFC), *Escherichia coli* count (EC), *Shigella* count (SC) and *Listeria* count (LC)] during 0-5 days of storage using standard laboratory methods. All samples were stored at freezing (FZ), refrigeration (RF) and ambient (AB) temperatures of $-5\pm 2^{\circ}\text{C}$, $4\pm 2^{\circ}\text{C}$ and $27\pm 2^{\circ}\text{C}$ respectively. The DNA of the isolated bacteria obtained was extracted, sequenced and identified. The control samples (eviscerated and non-eviscerated) had TFC (2.15 and 2.7 log cfu/g) and TPC of (2.24 and 3.25 log cfu /g) respectively. During RF and FZ storage, the EC, LC and SC reduced in the NEVS but were not detected in the EVS during storage. However, EC, LC and SC were lower in EVS than in the NEVS at AB, indicating that non-evisceration of this fish contributed to its high microbial load. The molecularly identified bacteria include: *Klebsiella pneumoniae*, *Shigella dysentery*, *Escherichia coli*, *Salmonella enterica*, *Staphylococcus aureus*, *Listeria grayi* and *Vibrio vulnificus*.

Keywords: Evisceration, Smoked fish, Microbial, Temperature.

Introduction

Fish, which can be eaten fresh, preserved or processed (smoked) forms a much-cherished delicacy that cuts across socio economic, ages, religious and educational barriers (Onyia, *et al.* 2014; Adebayo-Tayo *et al.*, 2008). It is a major source of animal protein and an essential food item in the diet of Nigerians because it is relatively cheaper than meat. Smoking is one of the methods of preserving fish for centuries, especially in the developing countries. Smoking is a penetration process of volatile compounds from smoking resources into fish flesh (Palm *et al.* 2011). Smoked fish constitutes an important diet of many consumers in the developing world. However, the safety of the traditionally smoked fish is becoming a major public health concern. This study investigated the microbial qualities of non-eviscerated smoked Blue Whiting fish (*Micromesistius poutassou*) during storage.

Materials and methods

Samples of non-eviscerated smoked fish were collected aseptically from five (5) different processors selected randomly in Makoko, Lagos, Nigeria. Laboratory prepared eviscerated (EVS) and non-eviscerated smoked fish (NEVS) served as control samples. The microbial qualities [total plate count (TPC), total fungal count (TFC), *Escherichia coli* count (EC), *Shigella* count (SC) and *Listeria* count (LC)] were determined during 0-5days of storage using standard laboratory methods. Smoked fish samples from processors and the control samples were stored at freezing (FZ), refrigeration (RF) and ambient (AB) temperatures of $-5\pm2^{\circ}\text{C}$, $4\pm2^{\circ}\text{C}$ and $27\pm2^{\circ}\text{C}$ respectively during which they were subjected to microbiological analysis. The DNA of the isolated bacteria obtained was extracted, amplified with 16s rRNA primers, sequenced and identified. Data obtained were subjected to analysis of variance (ANOVA). Differences among means was separated using Duncan's multiple range test; significances accepted at 5% level ($P\geq 0.05$) using statistical software SAS 9.0 (2008) for windows.

Results and Discussion

The control samples (eviscerated and non-eviscerated) had TFC (2.15 and 2.7 log cfu/g) and TPC of (2.24 and 3.25 log cfu /g) respectively. During RF and FZ storage, the EC, LC and SC reduced in the NEVS but were not detected in the EVS during storage. However, EC, LC and SC were lower in EVS than in the NEVS at AB. The molecularly identified bacteria include: *Klebsiella pneumoniae*, *Shigella dysentery*, *Escherichia coli*, *Samonella enterica*, *Staphylococcus aureus*, *Listeria grayi* and *Vibro vulnificus*. The phylogenetic analysis showed that the isolated bacteria are in association with *Klebsiella pneumonia* strain KPCSMDRLA 1, *Shigella dysentery* strain sd 197, *Acinetobacter oleivorans* strain JC 3 and *Vibro harveyi* strain HW 4 from the Gene bank.

Conclusion

The non-evisceration of this fish encouraged the growth of the microorganisms that are naturally present in the visceral organs, thus contributing to its high microbial load.

Table 1: General microbial enumeration of fresh (non-eviscerated) and smoked (eviscerated and non-eviscerated) blue whiting fish (Logcfu/g)

Samples	TPC	EC	TFC	SC
A	4.19 ± 0.01^c	4.23 ± 0.01^a	4.15 ± 0.01^{ab}	4.54 ± 0.00^b
B	5.63 ± 0.01^d	4.34 ± 0.01^{ab}	2.89 ± 0.03^c	5.34 ± 0.00^a
C	5.71 ± 0.01^{ad}	4.42 ± 0.01^{ac}	3.29 ± 0.02^b	4.48 ± 0.00^{bc}
D	5.80 ± 0.02^{ac}	4.19 ± 0.01^c	4.35 ± 0.01^{ab}	5.00 ± 0.00^{ab}
E	6.51 ± 0.00^{de}	4.52 ± 0.01^{cd}	3.53 ± 0.00^b	5.49 ± 0.00^a
F	3.21 ± 0.01^b	4.20 ± 0.02^a	3.25 ± 0.01^{bc}	4.02 ± 0.00^c
T	2.24 ± 0.09^a	ND	2.15 ± 0.01^c	ND
K	3.25 ± 0.03^{bc}	ND	2.7 ± 0.01^c	ND

Data represents mean of three replicates, means on the same column with different superscripts are significantly different at $p \leq 0.05$. Microbial counts were in colony forming unit/gram of sample analyzed.

EC- *E.coli* count; SC-*Shigella* count; LC-*Listeria* Count; TPC -Total Plate Count; TFC -Total Fungi Count,

A-Smoked non eviscerated fish from cluster one in Makoko, Lagos; B- Smoked non eviscerated fish from cluster two in Makoko, Lagos; C- Smoked non eviscerated fish from cluster three in Makoko, Lagos; D- Smoked non eviscerated fish from cluster four in Makoko, Lagos; E- Smoked non eviscerated fish from cluster five in Makoko, Lagos; F- Fresh unsmoked fish; K Smoked non eviscerated fish control sample; T Smoked eviscerated fish control sample

ND-Not detectable

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MICROBIOLOGICAL QUALITY ASSESSMENT OF *NONO*; A NIGERIAN FERMENTED MILK PRODUCT

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ABSTRACT

Nono is locally processed fermented cow milk that contains high nutritional value. This study was evaluated the microbiological quality of *nono* sold in Minna metropolis, Niger State. Fourteen (14) samples of *nono* were collected from four different locations within Minna metropolis. Microbial isolations were carried out using spread plate method on Nutrient agar, MacConkey agar and Sabouraud Dextrose agar. Isolates were identified with standard protocols of colony morphology microscopic and biochemical analysis. Results revealed that the total microbial count of *nono* samples ranged from 4.4×10^6 cfu/mL to 10×10^6 cfu/mL which is above the safety limit of 10^6 cfu/mL. However, total fungal count ranged from 4.0×10^6 cfu/mL to 4.6×10^6 cfu/mL, total coliform count ranged from 4.6×10^6 cfu/mL to 5.2×10^6 cfu/mL and total bacteria count ranged from 4.8×10^6 cfu/mL to 5.4×10^6 cfu/mL were below the safety limit. The coliform count of *nono* samples were far above the permissive level of World Health Organization recommended standard of 1×10^1 cfu/mL for uncooked food or beverage. The results suggest that the *nono* samples were predominately contaminated by fungal and bacterial species. The prevalence of predominant microbial isolates in decreasing pedigree were: *Aspergillus niger* (20%), *Aspergillus flavus* (17.5%), *Staphylococcus* sp (15%), *Pseudomonas* sp (15%), *Escherichia coli* (15%), *Enterobacter* sp (7.5%), *Salmonella* sp (5%) and *Klebsiella* sp (5%). Results from this study revealed that *nono* was contaminated with microbes and the microbial contaminants were higher than the safety limits. Appropriate processing, handling practices and safety measures should be ensured by vendors to achieve healthier and safe *nono* for consumption.

Keywords; Bacteria, Coliform, Fungi, Milk Product, *Nono*

Introduction

Cow milk forms an important component of some traditional dairy dishes and beverages of the Fulani and Hausa tribes in northern Nigeria (Omotosho *et al.*, 2013). It is sometimes served raw immediately after milking or allowed to ferment for use as a major recipe in a popular staple beverage known as “*fura da nono*.” *Nono* has yoghurt-like taste (sharp acid taste), and can be taken with sugar and /or *fura* (cooked millet flour which is rolled into small balls). *Nono* production generally involves inoculating freshly drawn cow milk with a small quantity of leftover *nono* as starter, and then storing at room temperature for twenty-four hours. Dairy

products are highly nutritious which makes it an excellent growth medium for microorganisms which can lead to contamination and reduced shelf life. Noah and Salam (2020) observed that the production of fermented milk products such as *Wara*, *Nono* are characterized by reduced shelf life because they are an excellent growth medium for a wide range of microorganisms such as *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Mycobacterium bovis*, *Brucella abortus* and *Coxiella burnetii*, which leads to spoilage and diseases when consumed.

Dairy product could be a source of pathogenic or toxigenic microorganisms upon consumption. Retailed yoghurt commercially available in Minna metropolis, in a study carried out by Oyeleke (2012) was found to host microorganisms such as *Aspergillus flavus*, *Aspergillus niger*, *Enterobacter* spp, *Staphylococcus aureus* among others. Such dairy product would pose a dire health risk for the urban/ rural populace of Minna metropolis. There is growing health concern over the unhygienic manner of hand milking by some livestock farmers in the study area. Similarly, the habitual consumption of unpasteurized milk and its products presents considerable risk of milk-borne infections to consumers (Jan *et al.*, 2016). This study was thus carried out to assess the microbiological quality of some retail uncontrolled fermented *nono* samples sold within Minna metropolis, Niger State.

Materials and Methods

This study was carried out in Minna metropolis, the capital of Niger State. Minna is situated in the North central region of Nigeria and lies between latitude: 9°35'0.7980"N and longitude 6°32'46.7376"E at an altitude of 256m above sea level and has a land area of about 88km². It has a total of 29,484 square metre (76,363 km square), and a population of 479,000. The three major ethnic group are Nupe, Hausa and Gwari. Dairy samples used in this study were collected from various parts of Minna metropolis, Niger State. The locations for sample collection included Mobil (MN), SabonGari (SGN), Sabonkasuwa (SKN), Kpakungu (KN).

Sample Collection

A total of fourteen (14) *nono* samples were purchased from local vendors in four different locations in Minna consisting of Mobil (MN), SabonGari (SGN), Sabonkasuwa (SKN), Kpakungu (KN). Each sample from the vendor is a bulk sample of two (2) samplings. The samples were aseptically collected into sterile sample bottles, placed in ice packs and immediately transported to the laboratory without delay. All experiments for this study were carried out at the Microbiology Laboratory, Federal University of Technology Minna, using standard microbiological methods.

Isolation and estimation of microorganisms from *nono*

One milliliter (1 mL) of each of the milk sample was taken and added into test tube containing 9mL of sterile water and a serial 10-fold dilution was made until a dilution of 10⁻⁴ was obtained. The total bacterial, coliform and fungal count was carried out using spread plate technique. One milliliter (1 mL) of the 10⁻² and 10⁻⁴ dilution of each sample was aseptically transferred into sterile Petri dishes containing growth medium of Nutrient agar (NA), MacConkey agar (MAC), and Sabouraud dextrose agar (SDA) for bacterial and fungi respectively. The plates were incubated at 37°C for 24 hours for bacteria and 27°C for 3-5 days for fungi. This process was carried out in duplicates for each sample. The incubated plates were then screened for the presence of discrete colonies and the actual numbers of bacteria and fungi was estimated in

colony forming unit per mL (cfu/mL). Bacterial colonies that appear on NA plates after incubation were sub-cultured repeatedly on separate media plates (Eosin methylene blue agar and Mannitol salt agar) to obtain pure cultures which were stored on agar slants for identification and further analysis (Cheesbrough, 2006). Fungal isolates growth from SDA were subcultured twice to obtain pure culture and Lactophenol cotton blue was used in the identification protocol.

Estimation of the microbial load in samples

The microbial concentration is expressed in colony forming unit (cfu) per mL of sample, which is an estimate of viable bacteria or fungal cells in a sample. Colony forming unit was calculated using Equation 1:

$$Cfu/mL = \frac{\text{Number of colonies} \times \text{Dilution factor}}{\text{Volume plated}} \quad (1)$$

Characterization of microbial Isolates

Bacterial isolates stored on agar slants were characterized by standard protocols of colony morphology and conventional biochemical tests including Gram staining, Oxidase, Indole, Vogesproskauer, Methyl red, Citrate, Catalase, Starch hydrolysis, Urease, Coagulase, Motility and Sugar fermentation test. Fungal isolates were identified based on colony morphology and microscopic analysis (Mbaeyiet *al.*, 2011; Omotosho *et al.*, 2013).

Results and Discussion

Results presented in Figure 1 showed the microbial load recorded. The total microbial count (TMC) 10×10^6 cfu/mL is above the non-coliform food safety limit of 10^6 cfu/mL and significantly ($p < 0.05$) higher than WHO limits for uncooked beverages, while total fungi count 4.6×10^6 cfu/mL and total bacteria count 5.4×10^6 cfu/mL were below the non-coliform food limit. However, the total coliform count 5.2×10^6 cfu/mL was higher than the WHO acceptable limit for coliforms in food drinks. During sales of *nono*, different bowls and hands are dipped into the bucket to collect the product. The unsanitary environment of these products display for sales to consumers is also another source of contamination which is in agreement with Shittu *et al.* (2016).

Prevalence of microbes in *nono* is represented in Figure 2, with *Aspergillus niger* having the highest prevalence of 20%, followed by *Aspergillus flavus* (17.5%), *Staphylococcus* sp, *Pseudomonas* sp and *Escherichia coli* at 15% each, *Enterobacter* sp at 7.5%, *Salmonella* sp and *Klebsiella* sp were the least at 5% each. The fungal isolates of this study were similar to the report Sule *et al.* (2015) and are known spore formers which means they contaminate the product during processing, storage and hawking. However, their growth can result in the production and accumulation of mycotoxins which are of public health and economic importance.

The detection of *Enterobacter* sp, *Klebsiella* sp and *Escherichia coli* in these products were similar to the report of Shittu *et al.* (2016) and Uzeh *et al.* (2006) which is an indicative of possible faecal contamination. This is as a result of poor hygienic processing practices by the handlers, quality of water and utensils used for the *nono* showcasing and sales. *Staphylococcus* sp was noticed in the sample similar to the report of Sule *et al.* (2015) who implicated *Staphylococcus* sp as a major spoiler of dairy products and a public health importance. It has the ability to cause a wide range of infections especially food borne intoxication.

The result obtained from the microbial analysis of *nono* shows that locally processed dairy products are contaminated with microorganisms of public health concern. The high total bacterial and coliform count in *nono* may be due to the low level of hygiene maintained during the processing and sale of the products.

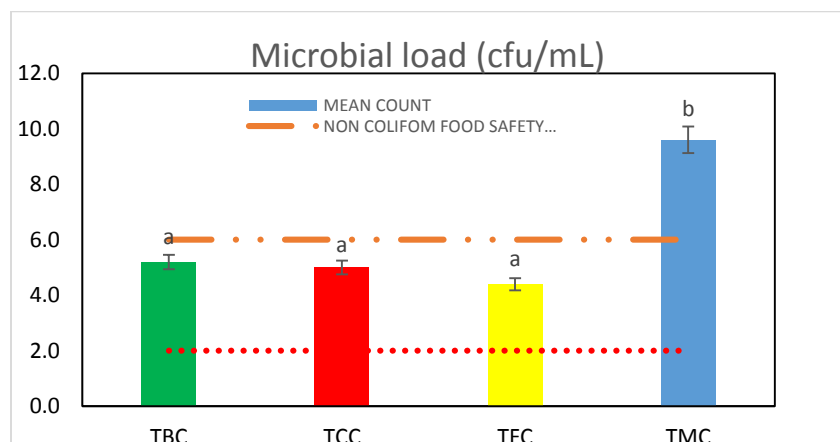


Figure 1: Mean microbial load of *nono* samples

Key: TBC = Total bacterial count; TCC = Total coliform count; TFC = Total fungi count; TMC = Total microbial count

NB: Bars with different alphabets are significantly different ($p < 0.05$)

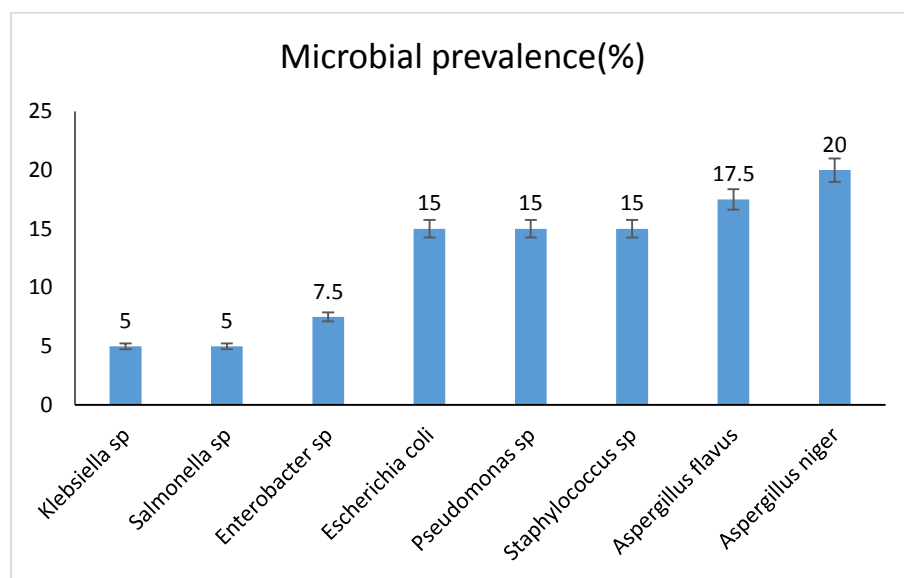


Figure 2: Microbial prevalence in *nono* samples

Conclusion and Recommendation

Nono in this study harbors microbes which include *Staphylococcus* sp, *Pseudomonas* sp, *Salmonella* sp, *Aspergillus niger*, *Aspergillus flavus*, *Escherichia coli*, *Enterobacter* sp and *Klebsiella* sp. The microbial count of *nono* samples were above the acceptable limit.

Based on the present study, the following recommendation were made in order to maintain the quality of *nono*. Care should be taken not to use contaminated water in the course of production and contact with soil or dust should be avoided. Food handlers with open wounds should not be involved either in the production or sales of these products. Utensils used for the preparation and consumption of *nono* should be properly washed before and after each use to limit fecal and mycotoxin contamination from air and flies while hawking. Rings and other jewelries especially those worn on the fingers and wrist should not be worn during *nono* preparation and sales as they can harbor dirt and germs. Regulated bodies should supervise the production process and environment in which *nono* is sold with appropriate education on best practices.

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MOLDS AND MYCOTOXINS IN FOOD VALUE CHAIN: A CHALLENGE TO FOOD AND NUTRITION SECURITY

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Abstract

Urbanization in Africa is on the increase and most of the food materials are produced in the hinterlands. Due to postharvest losses on fresh produce, however, many of the farmers therefore apply simple and affordable open sun-drying between harvest and the consumers. However, due to high atmospheric moisture in the tropics during the raining season, controlling product dryness and quality in stored foods and feeds becomes difficult. Knowledge of the importance of moisture in mold control to enhance food safety and prevent food spoilage. This study, mold associated with drying of plantain chips, post-drying handling of catfish and cassava peels were isolated and characterized using standard laboratory procedures. Mold species isolated included; *Aspergillus flavus*, *Rhizopus sp.*, *Aspergillus niger*, *Fusarium sp.*, *Penicillium digitatum*, *Aspergillus fumigatus*, *Mucor sp.*, *Neurospora sp.*, and *Penicillium sp.* These fungi possess health risks because of mycotoxin-production tendency. In conclusion, slow drying provides avenue for microbial growth and toxin production which is a major problem associated with food, food value and supply chain in our society. At a time when alot of resources (Government, NGOs and civil society) are targeted towards improving consumer health via food systems, adequate precautions, education of farmers, environmental condition management becomes relevant.

Keywords: *Fungi, Moisture, Consumer, humidity and safety*

Introduction

In developing country like Nigeria, farming activity is increasing due to dare need to feed the ever-growing population. Several of these population lives in the urban areas needing alot

of food material supplies for him and the livestock. Fish is one of the most nutritious food sources for human due to their high protein content. As such, they are very suitable for microorganisms as growth medium (Lina *et al.*, 2021). The growth of these organisms coupled with lipid degradation often leads to the spoilage of this important product. High environmental temperature and moisture often create the conducive conditions for this deterioration which eventually reduce the quality of fish and its keeping time and shelf life. (Sean *et al.*, 2015). Plantain chips is known to be a popular dietary staple food in many parts of Central and West African countries due to its versatility and excellent nutritional value. The mature, unripe plantain finger is processed into dried chips by processors using open sun-drying method to reduce the moisture content so as to extend its shelf life and keeping quality (Marina *et al.*, 2019).

Cassava is one of the cheap sources of carbohydrate in the diet of the third world countries where it is largely grown. Owing to high demand for this product, the cultivation has increased in the past years. The peel which is the major waste generated from processing of cassava root is used in livestock feeding, serving as a source of energy (Okike and ,2015).

In this part of the world, farm produces are usually in abundance during the raining season thereby making foods to become surplus, leading to either wastage or farmers are forced to sell at cheap prices leading to serious loss of input capital, profit and effort. Slow drying especially during the high-humid period results in mold build-up by different types of microflora and subsequent associated health risks. Controlling moisture can prevent fungi growth. Therefore, the aim of this study was to assess fungi associated with dried catfish, plantain chip and cassava peels during open sun-drying and storage, as well as the health risks from mycotoxin-producing molds.

Materials and Methodology

Sample Collection

A total of ten (10) African catfish were randomly obtained from River Niger bank, Marine Road in Lokoja where drying of fish are done by some local processors. Five (5) plantain chips undergoing open sun-drying were also randomly collected and were carefully packed into polythene bags separately and labelled. Open sun drying cassava peels were obtained from Garri processing Centre at Lokongoma Phase II. All the materials were transported to microbiology laboratory for mycological analysis.

Isolation and characterization of Fungi

One gram (1g) each the samples was taken and crushed in a mortar with pestle respectively and added to nine millilitres sterile peptone and serially diluted up to 10^{-6} fold. Afterwards, 1ml from 10^{-2} , 10^{-4} and 10^{-6} suspension of the samples (Catfish, Plantain chips and cassava peels) was pour- plated using freshly prepared potato Dextrose Agar previously modified by adding

Chloramphenicol antibiotics to suppress bacteria growth. The mixture was then gently swirled to mix and allowed to gel after which the plates were incubated at 28°C for 3-5 days. After incubation period, the discrete colonies that emerged were counted, characterized, purified by sub-culturing several times and then the pure cultures were maintained on the modified PDA slants as stock until further use. The fungi isolated were identified microscopically using simple staining techniques where 2-3 drops of Lactophenol Cotton Blue stain were added to a cut portion of the growing fungi under cover slip and observed with oil immersion under the microscope. Biochemical tests were carried out according to the methods described by Harrigan and McCance (1976) as well as Seeley and Van Demark (1972) on morphology, motility, spore staining, catalase, coagulase production, starch hydrolysis and sugar fermentation (Onyeze *et al.*, 2019).

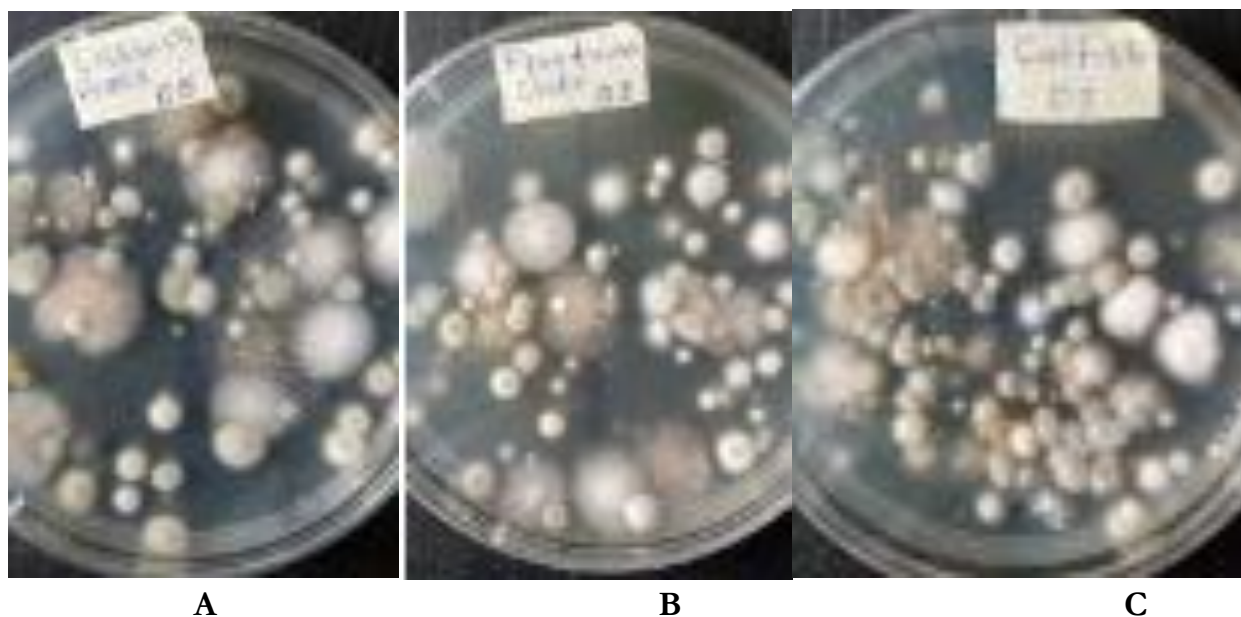
Statistical analysis

Data obtained from the experiment were subjected to one-way analysis of variance (ANOVA) using SPSS 13.0 for window. Differences between the means were determined using Duncan's multiple range test at 95 % confidence level ($p=0.05$)

Results and Discussion

Enumeration of Fungi

Colonies which developed after incubation were subjected to counting. The total fungal counts were expressed as spore/g.



A **B** **C**
PDA Plates showing the 48-Hour Discrete Fungi Colonies from the Samples; A: Cassava peels, B: Plantain chips and C: Catfish

Fungi load of the selected food/feed Samples

Table1 shows the mean total viable counts of fungal isolates in the products. The count on catfish were 1.4×10^6 CFU g⁻¹, plantain chips had 2.7×10^6 while cassava peels recorded 3.2×10^6 . Cassava peels has the highest fungal load followed by plantain chips while catfish recorded the lowest number. The pie-chart of the relative occurrence of the fungi is shown in Figure I.

Mean Fungi load of the Food/Feed Obtained from the Markets

Product: Catfish:Fungal Load (Spore/g) $\times 10^4 = 1.43$, Plantain chips, Fungal Load (Spore/g) $\times 10^4 = 2.71$, Cassava peels: Fungal Load (Spore/g) $\times 10^4 = 3.23$

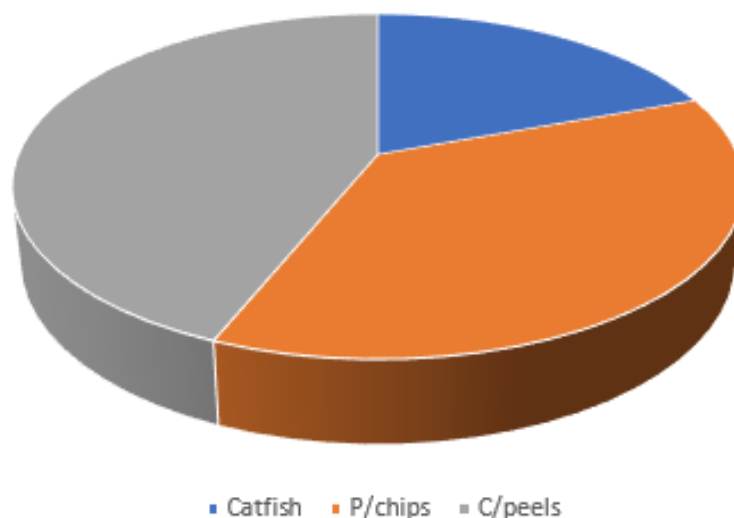


Fig 1: Occurrence of Fungi on the Food/Feed Samples

Table 1 shows the fungi associated with the respective food types obtained from the open drying processing in the market. *Aspergillus niger* and *Fusarium sp.* were present in all the food/feeds studied. *Mucor sp.* and *Neurospora sp.* were present only in plantain chips.

Table 1 : The Fungal Isolates Associated with the Samples Understudy

Fungal Isolate	Food/Feed Sample		
	Catfish	Plantain chips	Cassava peels
<i>Aspergillus flavus</i>	+	-	+
<i>Rhizopus sp.</i>	+	+	-
<i>Aspergillus niger</i>	+	+	+
<i>Fusarium sp.</i>	+	+	+
<i>Penicillium digitatum</i>	+	-	-
<i>Aspergillus fumigatus</i>	-	+	+

<i>Mucor sp.</i>	-	+	-
<i>Neurospora sp</i>	-	+	-

Key: += Present; - = Absent

It can be concluded from the results of this study that all is not well with the food materials studied owing to the fungi quality present on the three products; Catfish, plantain chips and cassava peels processed in the market surveyed. The isolation of pathogenic and spoilage fungi such as *Aspergillus flavus* in this work raises public health concerns about safety in consuming the products because of the mycotoxins they might contain. The presence of the identified fungi in the products is attributed mainly to the high moisture contents of the atmosphere followed by poor handling by the processors. The 1.4×10^6 CFU g⁻¹, 2.7×10^6 and 3.2×10^6 recorded exceeded the range of specified microbiological limits recommended for products meant for human consumption (Robertset *al.*, 1996). The ICMSF protocol recommends a maximum microbial count of 5×10^5 for good quality product and a maximum count of 10^7 for marginally acceptable quality products. In the same vein, the moisture content levels which ranged between 4.8% and 6.5% was above the recommended moisture levels for foods meant for storage because they are also prone to attack and deterioration by microorganisms.

Conclusions

It was concluded that the foods and feed products processed in the market/ centres in Lokoja, Kogi State Nigeria was contaminated with pathogenic and spoilage fungi and that the fungi thrived due to the presence of high humidity. Our findings indicated shows both storage and public health implications owing to the types of fungi present on the food materials. Therefore, the concerned food and feed processors, vendors and the consumers should improve handling hygiene and consumers should further dry the products before long storage to minimize microbial growth in other to tackle the risk that mycotoxin producing molds have on food and nutrition security.

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POPULATION DYNAMICS OF LACTIC ACID BACTERIA AND YEAST DURING FERMENTATION OF SWEET POTATO CULTIVARS

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ABSTRACT

Fermentation is an economic processing method used in homes to improve the nutritional quality of plant foods. It is the most current process of food by-product valuation. Fermentation improves nutritional value, hygiene and sanitary qualities, food preservation, energy density and organoleptic characteristic of food. Sweetpotato flour were prepared by the fermentation of two different cultivars (TIS87/0087 and TIS 2532.OP.1.13) of sweetpotato (*Ipomoea batatas*) roots for 24 hours. The microbiological, pH and titratable acidity of the fermenting medium were assessed. Bacteria isolated from the fermenting medium were *Lactobacillus plantarum*, and yeast, *Saccharomyces cerevisiae* respectively. The yeast profile ranged from $2.50 \times 10^2 \text{ cfu g}^{-1}$ to $(<10^2 \text{ cfu g}^{-1})$ for TIS87/0087 and from $2.62 \times 10^2 \text{ cfu g}^{-1}$ to $2.60 \times 10^2 \text{ cfu g}^{-1}$ for TIS 2532.OP.1.13. The lactic acid bacteria counts ranged from 2.49×10^2 to $3.95 \times 10^3 \text{ cfu g}^{-1}$ for TIS87/0087 and 3.48×10^2 to $4.35 \times 10^3 \text{ cfu g}^{-1}$ for TIS 2532.OP.1.13. The percentage titratable acidity for both sweet potato cultivars were observed to increase from 0.51% to 4.96% for TIS 87/0087 and 0.40% to 4.04% for TIS 2532.OP.1.13 as fermentation progressed in relation to the fall in pH. This reveals that sweet potato could be fermented with yeast starter culture and lactic acid bacteria under controlled condition.

Key words: Sweet potato, Fermentation, Microbial flora, pH, Flour

INTRODUCTION

Sweet potato (*Ipomoea batatas*(L.) Lam) is an extremely important crop in different parts of the world and has become a high value and feed crop grown in diverse ecologies (Fironet *et al.*, 2009) in sub Saharan Africa, where it plays a food security role. The tuber is rich in Vitamin C with Vitamin A and B being present in significant amounts. In processing of foods, fermentation is been identified as an economic processing method that could be used in the homes to improve the nutritional quality of plant food. It involves the activities of microorganisms (bacteria and fungi) in the production of food. Microbes decompose fermentable starch into final products like organic acid, carbon dioxide, and alcohol throughout fermentation, Kim *et al.*, (2016), also anti-microbial metabolites like bacteriocins that enhances food security by inhibiting food pathogens (Nout, 2014). Fermentation aids in the protection of food, especially highly perishable food and increase the organoleptic constituents of food. Fermentation improve the appearance of some foods such as flours, decrease cooking time and help in digestion proteins and carbohydrates and make available minerals and vitamins. Fermentation process involve little waste and the techniques used are inexpensive and simple. Due to these advantages, fermented food and beverages are portion of the human nutrition from antiques remain vital in evolving nations where they are part of native cultures and traditions Borresen *et al.* (2012). Lactic acid bacteria have been reported to be predominant microorganisms in most of the

African indigenous fermented foods (Duhan et al., 2013). Yeasts are eukaryotic microorganism, unicellular, diverse in nature found in a wide variety of habitat. Yeast converts carbohydrates to carbon dioxide (CO₂) and alcohol. They are used in baking, wine making, brewing and a large variety of industrial products. Yeast and wide varieties of bacteria were found to be associated with fermentation of cassava and cereal grains were they contribute to starch breakdown, acidification, and detoxification and flavor enhancement³. However, yeast and lactic acid bacteria are therefore the most common microorganisms in a wide variety of traditional food and beverage fermentation. The preservation characteristics of lactic fermentation depend on the conversion of sugar substrate in food to lactic acid which then lowers the pH and increase the level of acidity of the food and preventing the growth of most other bacteria (Amajor, *et al.*, 2011). The objective of this study was to determine the population dynamics of the lactic acid bacteria and yeast during fermentation of sweet potato to flour.

MATERIALS AND METHODS

Two sweet potato cultivars Tis 87/0087 and Tis 2532. OP.1.13 were used in the study and were harvested from the production fields of National Root Crops Research Institute (NRCRI) Umudike and taken to food laboratory for processing.

The sweet potato roots (20kg) were washed, peeled and rewashed. The peeled sweet potato were cut into 3.0-3.5mm thickness with the use of a chipping machine. The chips were put into a 25 liter basin and labelled. The chips were soaked and allowed to ferment at ambient temperature for 24 h. At 0 h and 4 h intervals for 24 h period samples were taken from the fermenting medium for analysis. Sample pH and TTA were determined and samples were cultured on potato dextrose agar (PDA) for 2-5 days for yeast growth and count. Lactic acid bacteria (LAB) were grown on MRS Agar for three days. The colony counts were expressed in Cfu/ml and the morphology of different colonies were sub- cultured on the agar slants for biochemical and identification test.

RESULTS AND DISCUSSION

Lactic acid bacteria and yeast were isolated from sweet potato in line with a previous study where LAB were isolated from sweet potato (Panda *et al.*, 2007). The highest count of LAB as recorded for both samples at 4 h of fermentation and the least count at 8 h of fermentation (Table 1). The pH at 4 h may have been optimal or favorable for growth for both cultivars. The result indicated that LAB fluctuated in numbers during fermentation period irrespective of cultivars. The pH of the sweet potato fermenting slurry decreased with increased fermentation time probably due to the metabolic activities of the microorganisms, leading to increased acidity. The proliferation of yeast in food is favored by the acidic environment as shown in the study at 12 h. Table 2 shows the total yeast counts Cfu/ml during fermentation of the cultivars. The yeast counts showed significant difference ($p < 0.05$) from 12 h to 24 h for Tis 87/0087 while the yeast for Tis 2532.OP.1.13 showed no difference in counts at 12 h and 24 h period of fermentation. Changes in yeast counts may be due to the gradual decrease

in pH and increase in lactic acid production. Co- metabolic of yeast and lactic acid bacteria have been reported by (Steinkraus,1996) suggested growth of yeasts in food been favoured by acidic environment created by LAB while the growth of LAB is stimulated by the presence of yeast which provide growth factors such as vitamins. The association of yeast and LAB may also contribute to secondary metabolites which cloud improve taste and flavor of foods Brauman *et al.* (1996).

Table 1: Lactic acid bacteria (LAB) profile during fermentation of sweetpotato cultivars.

Fermentation time (hours)	Cultivars	
	TIS. 87/0087	TIS 2532.OP.1.13
0	2.49± 1.13 ^g x 10 ²	3.48 ± 0.42 ^g x 10 ²
4	8.46± 0.99 ^d x 10 ²	9.48 ± 1.41 ^c x 10 ²
8	1.95 ± 1.69 ^c x 10 ³	2.14 ± 0.71 ^b x 10 ³
12	3.95± 1.56 ^a x 10 ³	4.35 ± 0.14 ^a x 10 ³
16	3.65± 0.71 ^b x 10 ³	3.85± 2.83 ^f x 10 ²
20	4.20± 1.27 ^f x 10 ²	4.72 ± 2.82 ^e x 10 ²
24	5.80 ± 0.98 ^e x 10 ²	6.14 ± 0.98 ^d x 10 ²

Values in column with different superscripts are significantly different (p<0.05)

Values are means ± SD of three different determinations.

Table 2: Yeast profile during fermentation of sweet potato cultivars.

Fermentation Time (hours)	Cultivars	
	TIS. 87/0087	TIS 2532.OP.1.13
0	-	-
4	-	-
8	-	-
12	2.50± 2.12 ^c x 10 ²	2.62± 2.12 ^c x 10 ²
16	3.44 ± 0.71 ^b x 10 ²	4.38±2.10 ^b x 10 ²
20	4.40± 0.70 ^a x 10 ²	5.46 ± 0.00 ^a x 10 ²

Values in column with different superscripts are significantly different (p<0.05).

Values are means ± SD of three independent determinations.

CONCLUSION

During fermentation of sweet potato, pH decreased with a progressive increase in acidity. Lactic acid bacteria and yeast were isolated from sweet potato slurry and were identified as *Lactobacillus* spp and *Saccharomyces cerevisias* respectively. There was succession of microorganism during fermentation. This reveals that sweet potato could be fermented with yeast starter culture and lactic acid bacteria under controlled condition.

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ISOLATION AND MOLECULAR IDENTIFICATION OF LACTIC ACID BACTERIA FROM BAMBARA NUTS AND TAMARIND FRUIT

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ABSTRACT

Lactic acid bacteria are widespread microorganisms found in environment rich mainly in carbohydrates. This study was aimed at isolation and identification of lactic acid bacteria from Bambara nuts and Tamarind fruit using pour plate method and 16S rRNA sequencing technique. Results revealed the total bacterial count from Bambara nuts grit coded (B1 to B3) ranged from $4.3 \log^{-1}$ to $5.7 \log^{-1}$ CFU/g while Tamarind fruit samples coded (B21 and R32) ranged from $4.2 \log^{-1}$ to $4.9 \log^{-1}$ CFU/g. Strains of *Weissella paramesenteroides* and *Lactobacillus pentosus* 124-2 were isolated from Bambara nuts while *L. plantarium* strain CIP103151 and *L. plantarium* strain JCM1149 were isolated from Tamarind fruit pulp. Results from this study indicate that Bambara nuts grit and Tamarind fruit pulp contain predominant lactic acid bacteria.

Keywords: Bambara nuts grit, Isolation, Lactic acid bacteria, Tamarind fruit pulp, 16S rRNA.

Introduction

Identification is the process of determining to which established taxon a new isolate or unknown strain belongs. Isolation refers to the separation of a strain from a natural, mixed population of a living microbes as present in the environment. Bacterial isolates are identified for several practical reasons ranging from identifying microbial contaminant responsible for food spoilage or identifying new isolates which carries out an important process (Adeoye *et al.*, 2018). Streaking and pour plate methods are two main ways of isolating organisms (Kazeem *et al.*, 2021). During the last decades, alternative means of characterizing bacteria have emerged based on comparison of nucleic acid sequences (Adnan *et al.*, 2021). This method is particularly useful in providing information about the evolutionary relationships among bacteria.

Microorganisms isolated from native microbiota of traditional products are usually selected as starter cultures due to their broad adaptability to the environmental conditions of food processing. The organisms confer some characteristics such as specific appearance, aroma, texture and flavor (Ohaegbu *et al.*, 2022). The most predominant lactic acid bacterial species isolated from milk, cheese, yoghurt, *ogi*, Sauerkraut, fish, meat, fermented cereals and tubers include *Lactobacillus bulgaricus*, *Streptococcus thermophiles*, *L. planetarium*, *Leuconostoc mesenteroides*, and *L. acidophilus* (David *et al.*, 2019).

Bambara and Tamarind have the potential to serve as a source of balanced diet especially in instances where animal protein is expensive or scarce and legumes cultivation fail due to low rainfall (Ogodo *et al.*, 2018 and Chimsah *et al.*, 2020). Bambara nut (*Vigna subterranean* L.) is an indigenous crop to Africa (Ogodo *et al.*, 2018). It is native to north eastern Nigeria as well as northern Cameroon. It belongs to the *Leguminosae*, subfamily *Papilionoideae* (Khan *et al.* 2021). Bambara nuts are underutilized plants that are not rated as commodities in the global trading scheme, frequently grown on marginal land and in surviving farms by women (Khan *et al.*, 2021).

Tamarind (*Tamarindus indica* L.) is a neglected indigenous fruit tree with many valuable properties. Almost every part of the tree is utilized by rural and urban dwellers (Narina *et al.*, 2019). It belongs to the family *Fabaceae*. Tamarind tree can withstand drought conditions as it is well adapted to semi-arid regions of the tropics (Chimsah *et al.*, 2020). Adamu *et al.* (2022) reported the use of Tamarind for backslopping. Kazeem *et al.* (2021) also reported the production of yoghurt originating from plant sources such as Bambara nuts as a substitute to animal protein. In this study, pour plate and molecular methods were employed to isolate and identify lactic acid bacteria associated with Bambara nuts grit and Tamarind fruits pulp.

Materials and methods

Sample collection and identification

Bambara nuts were purchased from kure market in Minna, Niger State, Nigeria. Dry Tamarind fruits were manually harvested from Tamarind plant in Chanchaga Local Government Area, Minna. The samples were transported in a SC Johnson Ziploc bags, Bay city, Michigan to Microbiology Laboratory Federal University of Technology, Minna. Samples were identified by ethnobotanist in the Department of Plant Biology.

Bacterial Isolation

Lactic acid bacteria (LAB) were isolated from Tamarind fruit pulp by soaking 3g of the fruit pulp in 5mL distilled water. One millilitre of the Tamarind fruit pulp solution was dispensed in 9 mL of distilled water to obtain 10^{-1} dilution. Subsequent dilution was done up to 10^{-6} . Bambara nuts grit was similarly treated. The diluents (10^{-3} , 10^{-4} , 10^{-6}) were plated on de Mann Ragosa and Sharpe media (MRS agar). Plates were incubated anaerobically at 37°C for 48 hours. All strains were stored at -80°C in MRS agar, containing 25% (v/v) of glycerol as a cryo-protector, according to the method described by David *et al.* (2019).

Biochemical characterization of bacterial isolates

Microscopic examination for cell morphology was carried out and the distinct pure colonies observed were tested for Gram reactions. The following biochemical tests were conducted in conjunction with motility test, catalase, oxidase, urease production, citrate utilization, sugar fermentation, spore formation, methyl red (MR), and Voges-Proskauer (VP) according to David *et al.* (2019) and Kazeem *et al.* (2021).

DNA extraction

Lactic acid bacteria were sub cultured on MRS media and incubated at 30°C for 48 hours. The selected isolates were identified on the basis of their morphological and acid production characteristics. Using an Invisorb Spin DNA Extraction kit version 1017 Berlin, Germany, the DNA of LAB isolates were extracted and purified according to Ohaegbue *et al.* (2022).

Amplification of 16S rRNA of isolates

Each polymerase chain reaction (PCR) reaction mixture consisted of 12.5 µl mastermix (2x JENA Ruby hot start mastermix), 1 µl 27F 5'AGA GTT TGA TCM TGG CTC AG3' and TAC GGY TAC CTT GTT ACG ACT T 3', 1 µl DNA template and 9.5 µl reaction volume of 25 µl. Polymerase chain reaction amplification was carried out in an Applied Biosystem 2720 Thermocycler. The mixture was subjected to an initial denaturation at 94°C for 3 mins; followed by 35 cycles of denaturation at extension at 72°C for 60 seconds; and a final extension at 72°C for 10 mins. The PCR products were visualized on a 2 % agarose gel containing ethidium bromide in 0.5x Tris-borate buffer (pH 8.0) using blue led transilluminator (image attached). A molecular ladder marker (Jena Bioscience, 200bp) was run simultaneously to determine the size of the amplicons. The PCR products were purified and sequenced by Sanger sequencing method using AB1 3730XL sequencer. The gene sequence was also analysed in NCBI website (<http://www.ncbi.nlm.nih.gov>) using BLAST Software in the GenBank according to Adnan *et al.* (2021).

Results and Discussion

Table 1 shows the bacterial count of Tamarind fruit pulp and Bambara nuts grit. Tamarind samples B2, R33, B21 and R32 had bacterial counts of 4.2 log⁻¹ CFU/g, 4.2 log⁻¹ CFU/g, 4.9 log⁻¹ CFU/g and 5.8 log⁻¹ CFU/g respectively. Bambara bacterial counts for B1a, B1b and B12 were 4.3 log⁻¹ CFU/g, 4.7 log⁻¹ CFU/g and 5.7 log⁻¹ CFU/g respectively. The bacterial counts obtained in this study was lower than the total bacterial count of 1.26 × 10⁵ CFU/g (6.1 log⁻¹ CFU/g) observed within 48 hours in dried Bambara nuts by Kazeem *et al.* (2021). Adamu *et al.* (2022) reported bacterial count of 8 × 10³ CFU/g (3.9 log⁻¹) from Tamarind fruits pulp, a value that is lower than those obtained from the current investigation.

Table 1: Total colony counts for Tamarind fruit pulp and Bambara nuts grit

B1a, B1b, B12, and B3: isolates from Bambara nuts grit. B2, B21, R32 and R33: isolates from Tamarind fruits pulp.

Biochemical characteristics of bacterial isolates from Bambara nuts grit and Tamarind fruit pulp

The isolates were Gram positive, catalase, oxidase, citrate, urease, methyl red and VogesProskauer negative. Isolates were also non-motile and non-spore formers. Some of these isolates were cocci and rods. David *et al.* (2019) isolated similar organisms that were Gram positive, non- motile, non- sporulating and non -respiring cocci and rods from *Ogi* and *Nono* and concluded that these organisms produce lactic acid as their major end product

Sample code	Colony count (log CFU/g)
B1a	4.3
B1b	4.7
B2	4.2
B3	4.6
B12	5.7
B21	4.9
R32	5.8
R33	4.2

from carbohydrate fermentation. Adamu *et al.* (2022) observed the presence of Gram positive cocci and rods, catalase, oxidase, citrate, methyl red and indole negative, non -motile and non sporulating organisms from Tamarind and *Nono*.

Molecular identities of bacteria isolated from Bambara nuts grit and Tamarind fruit pulp

Figure I shows the sequenced amplicons of LAB isolated from Bambara nuts grit and Tamarind fruit pulp as the resulting alignment of the chain of nucleotides (from 5' 3' and 3' 5') with other known sequences previously BLAST from NCBI database. The 16s sequence generated from the isolates were aligned with sequences in this database and the sequences that produced similar alignment are assumed to be the identity of the isolate. The gel documented images of the isolated bacterial DNA after electrophoresis appeared at 1500kb which indicated pure isolates. Lane Mk represents molecular marker (ladder), lane B1a, B1bB12 and B3 represent DNA extracted from isolates in Bambara nuts grit and lane B2, B21, R32, and R33 DNA extracted from isolates in Tamarindfruit pulp as shown in figure I. In the current study, molecular characteristic using 16s rRNA confirmed the isolates B1a and B1b as strains of *Weissella paramesenteroides* NRIC 1542 in Bambara nuts grit while isolate R32 was confirmed as *Lactobacillus plantarum* strain JCM 1149 in Tamarind fruit pulp. The isolates B2, B3 and B12 were strains of *L. pentosus* strain 124-2 in both Bambara nuts grit and Tamarind fruit pulp. The isolates coded B21 and R33 were confirmed as *L. plantarum* strain CIP 103151 from Tamarind fruit pulp. These results are similar to the findings of Ohaegbue *et al.* (2022) from *Ogi* and *Fufu*. The direction of band migrated from negative to positive electrodes due to the

natural occurrence of negative charge carried by their sugar phosphate backbone (Adnan *et al.* 2021).

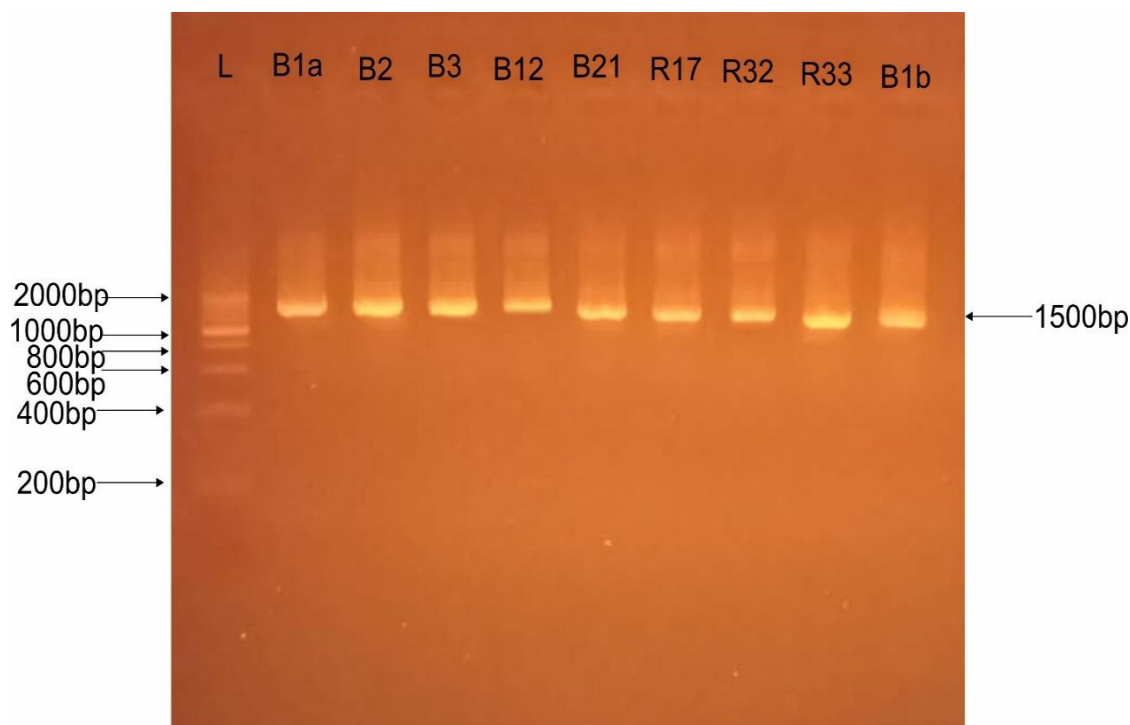


Figure I: Amplified image of the 16S rRNA gene of the LAB isolates from Tamarind and Bambara nuts **B1a/ B1b:** *Weissella paramesenteroides*, **B2/ B3/ B12:** *Lactobacillus pentosus* strain 124-2, **B21/ R33:** *Lactobacillus plantarum* strain CIP 103151, **R32:** *Lactobacillus plantarum* strain JCM 1149. **L:** Lane L represents the 1500 bp molecular ladder.

Conclusion

The isolated LABs were identified and characterized as *Weissella paramesenteroides*, *Lactobacillus pentosus* strain 124-2, *L. plantarum* strain CIP 103151 and *L. plantarum* strain JCM 1149.

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EFFECT OF STORAGE TIME ON THE PROXIMATE AND MICROBIAL LOAD OF PASTES FROM SOME VARIETIES OF TOMATOES GROWN IN A HYDROPONIC SYSTEM

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ABSTRACT

Tomato products are of considerable importance worldwide and the demand for tomato paste is increasing rapidly both in domestic and international market. Hydroponic method is a soilless technique for growing crops. It involves the growing of plants in a liquid nutrient solution with or without the use of artificial media. This study was carried out to evaluate the effect of storage period on the proximate and microbial load of paste from varieties of hydroponics (Cherry, Plum, UTC and Beefsteak) tomato paste; the pastes were kept at room temperature for shelf studies. The proximate and microbial analyses were carried out using standard methods. Each of the four varieties of tomato paste is significantly different in proximate analysis; moisture content was higher than other parameters analyzed irrespective of storage period. The bacteria count of the paste shows that the bacteria load of sample C (2.50×10^6 cfu/mL) has the lowest bacteria count when compared to the rest of the samples, while sample A (UTC tomato paste) had the highest bacteria load of 8.50×10^6 cfu/mL. There is no fungi growth in the four samples at 0, 14 and 28 days except that sample A had 1.15×10^6 cfu/mL fungi growth on the 28 days. On the 42 days sample A recorded high fungi growth to be 1.55×10^6 cfu/mL while sample C recorded 1.25×10^6 cfu/mL and sample B and D has no fungi growth. In recent years hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow short duration crop like vegetables round the year in very limited spaces with low labour, so hydroponics can play a great contribution in area with limitation of soil and water and for the poorer and landless people, result indicated that all samples showed significant different in proximate and microbes during storage at room temperature

Keywords: Hydroponics, Tomato paste, Proximate composition, Microbial, Storage

INTRODUCTION

Tomato (*Lycopersicon esculentum*), commonly referred to as vegetable to nutritionist and a fruit to plant scientists is grown throughout the tropical and temperate regions of the world (Okorie *et al.*, 2004). Tomato is an important herbaceous perennial vegetable grown for its edible fruit and as an annual vegetable in temperate regions. This fruit vegetable has the ability to raise the standard quality and acceptance of other diets and are consumed both as raw and/or processed products. Fresh tomatoes are the fifth most popular vegetable consumed in the United States (16.6 pounds per capita) (USDA, 2000). They are a good source of vitamins and minerals. It is also high in moisture and cellulose but low in protein. Production and consumption of tomato

around the world has increased tremendously over the past 25 years, a production of about 105 million tons in 2001 from an estimated hectares of 3.9 million was reported for fresh fruits by Ayandiji and Adeniyi (2011).

Hydroponics is a soilless technique for growing crops. It involves the growing of plants in a liquid nutrient solution with or without the use of artificial media (Bruce, 2015). The demand for hydroponically grown produce has rapidly increased in the last few years, it has been recognized as a viable method of producing vegetables for example tomatoes, lettuce, cucumbers and peppers as well as ornamental crops such as herbs, roses, freesia and foliage plants.

Tomatoes are highly perishable and large quantity of tomatoes is wasted due to poor handling/storage facilities. One of the methods used in most household in the preservation of tomato is the processing into tomato paste. The paste also represents the main product from industrial tomato cultivar. Tomatoes have short agricultural season and during the glut season much is transformed into paste and made available during the off-seasons. Due to rapid urbanization and industrialization not only the cultivable land is decreasing but also conventional agricultural practices causing a wide range of negative impacts on the environment. To sustainably feed the world's growing population, methods for growing sufficient food have to evolve. Modification in growth medium is an alternative for sustainable production and to conserve fast depleting land and available water resources (Butler and Oebker, 2006). There is sparse information on these hydroponically cultivated tomatoes and especially on the proximate and microbial properties of the paste. This study was aimed at evaluating the quality of the tomato paste with respect to the changes in proximate and microbial assessment during storage. This study can therefore help to manipulate the storage conditions and determine the safety of the pastes.

MATERIALS AND METHODS

Source of Material and Material Handling

Four varieties of tomatoes (Cherry, Plum, UTC and Beefsteak) were purchased from Soilless Farm Laboratory Owiwi, Abeokuta, Ogun State. They were properly packed in polyethylene packaged in carton and finally transported to the laboratory. Evaluation of the samples was carried out under strict and standard conditions in the Department of Food Science and Technology Laboratory of the Federal University of Technology, Minna, Nigeria.

Production of Tomato Paste

The tomatoes were sorted and washed to remove extraneous material and blanched at 90°C for 2 minutes for easy skin removal (peeled). The skins were removed manually followed by milling of the pulp in an attrition mill (until uniformly smooth mixture) and finally concentrating the tomato slurry at 100°C. It was sealed in aluminum steam pouch and then pasteurized at 70°C for 15 minutes. The packaged paste was labeled A (UTC), B (Cherry) C (Beefsteak) and D (Plum). These were then kept on shelf at room temperature for shelf studies.

Tomato pastes storage protocol

The tomato paste were stored at room temperature (cooled and dry place) 28°C on shelf and the evaluation of the paste were carried out at fourteen days (14 days) interval.

Proximate Analysis

The moisture, ash, fat and crude protein content of the various tomato pastes was determined using standard method described by AOAC (2010).

Microbiological Analysis

The microbial analysis was carried out on each sample for microbiological safety and all the media used were prepared aseptically in the laboratory following their manufacturers' descriptions. These included peptone water (PW), nutrient agar and potato dextrose agar. The media were weighed into different conical flasks and corked after the addition of distilled water. The media and tubes were autoclaved at a temperature of 121°C for 15 minutes using an autoclave (FSSAI, 2012). The cap of each of the sample bottles were opened aseptically and the necks of the bottles were flamed lightly before and after collecting the samples. Exactly 1 mL from each of the samples was transferred into six different test tubes containing 9 mL of peptone water each. From the first dilution, 1 mL of each sample was taken into a test tube. One mL was taken and transferred to the second test tube and shaken, the process was repeated until the last test tube labeled sixth. Thereafter, 20 mL of the molten sterile agar was transferred into a sterile petri dish and swirled gently for homogeneity. The molten agar was allowed to solidify and transferred into the incubator for 24 hours at 37°C for the bacterial enumeration. While fungi plates containing potato dextrose agar were transferred to the fungi hood and incubated at room temperature (28°C) for 48 h. The resulting growth of the cultures was counted as colony forming unit per mL (CFU/mL).

Statistical Analysis

Data obtained for bacterial load was tabulated using Microsoft Excel (MS Excel 2010, Microsoft Corporation). Statistical analyses were done on proximate data using Statistical Package for the Social Sciences (SPSS version 16.0). One way ANOVA using Duncan Multiple Range (DMR) test were used at 95% probability.

RESULTS AND DISCUSSION

The results of the proximate analysis are shown on Table 1. The results revealed that the moisture content ranged from 79.24% to 84.63%. The moisture content was higher than other parameters analyzed irrespective of storage period and this is in agreement with the findings of Agbema *et al.* (2015). As the storage period progress the quality of the protein is maintained except on the forty two days (42 Days) there is slightly significant difference and sample C recorded lowest protein with 4.96%. The crude protein content of all the varieties during storage ranged between 4.99 – 6.88% higher than 1.0% - 1.1% as reported by USDA (2005). The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production (Agbema *et al.*, 2015). The ash content of a food substance depicts the total crude minerals which ranged from 1.17% to 2.98% with sample A having the highest value. The ash content values are above the range of 0.47% - 0.98% reported by Agbema *et al.* (2015). As the storage time progress the four samples are

significantly different in ash content and could be as a result of its ability to absorb minerals from the medium or through nutrient manipulation as the tomatoes was said to be hydroponics and was not in agreement with the findings of Agbema *et al.* (2015). The four varieties had crude fat ranging from 0.33 – 0.55%, however, significantly higher than 0.20% reported by Idah *et al.* (2010). Agronomical activities during production may also account for dissimilarity.

The microbial quality of tomato paste is shown on Table 2. The bacteria count of the paste showed that the bacteria load of sample C (2.50×10^6 cfu/mL) had the lowest bacteria count when compared to the rest of the samples while sample A had the highest bacteria load of 8.50×10^6 cfu/mL. The low bacteria load of sample C gives a comparative advantage over others as it will stay longer maintaining its quality. However, for the fungi count no growth was observed in the four samples on 0 and 14 days of storage. No significant change was observed in 28 days except that sample A had growth to be 1.15×10^6 cfu/mL and on the 42 days sample A has 1.55×10^6 cfu/mL and sample recorded 1.25×10^6 cfu/mL. Bacteria load for sample C at 14 days was 4.05×10^6 cfu/mL while sample A had 8.15×10^6 cfu/mL and at 28 days 4.45×10^6 cfu/mL for sample C and 9.15×10^6 cfu/mL and 8.55×10^6 cfu/mL for samples B and A, respectively. These microbial profiles may be related to several interactive behaviours influenced by temperature, acidity and oxygen content. During the course of the microbial study, swollen pouches were observed for all the tomato paste after 6 weeks (42 days), and the study was terminated.

Table 1: Effect of storage on the proximate composition of the various tomato paste

Samples	Period (days)	Moisture	Protein (%)	Ash	Fat
A	0	80.26 ± 0.01^b	6.60 ± 0.01^b	2.71 ± 0.01^a	0.49 ± 0.01^a
B		80.74 ± 0.02^a	5.16 ± 0.01^c	1.21 ± 0.01^c	0.49 ± 0.01^a
C		80.12 ± 0.08^b	4.99 ± 0.01^d	1.98 ± 0.01^b	0.43 ± 0.01^b
D		79.24 ± 0.66^c	6.81 ± 0.01^a	1.17 ± 0.01^c	0.48 ± 0.01^a
A	14	80.39 ± 0.01^b	6.23 ± 0.01^b	2.85 ± 0.01^a	0.56 ± 0.01^a
B		80.85 ± 0.01^a	5.13 ± 0.01^c	1.34 ± 0.01^d	0.54 ± 0.01^b
C		80.19 ± 0.01^c	5.05 ± 0.07^c	1.49 ± 0.01^b	0.43 ± 0.01^d
D		80.43 ± 0.01^b	6.88 ± 0.01^a	1.39 ± 0.01^c	0.47 ± 0.01^c

A		81.63±0.01 ^c	6.18±0.01 ^a	2.98±0.01 ^a	0.34±0.01 ^d
B	28	81.74±0.01 ^b	5.10±0.01 ^c	1.72±0.01 ^b	0.51±0.01 ^a
C		82.46±0.01 ^a	5.04±0.00 ^d	1.42±0.01 ^d	0.39±0.01 ^c
D		80.47±0.01 ^d	6.17±0.00 ^a	1.55±0.00 ^c	0.41±0.01 ^b
A		84.63±0.01 ^a	6.11±0.00 ^a	2.74±0.00 ^a	0.33±0.00 ^d
B	42	84.12±0.01 ^a	5.94±0.00 ^b	2.05±0.01 ^b	0.47±0.00 ^a
C		84.41±0.01 ^a	4.96±0.01 ^d	1.98±0.00 ^c	0.36±0.00 ^c
D		83.62±0.01 ^b	5.17±0.00 ^c	1.72±0.00 ^d	0.38±0.00 ^b

Mean with the same superscript in the same column are not significantly different at ($p<0.05$). NG= No growth, A= UTC tomatopaste, B= Cherry tomatopaste, C= (Beefsteak) tomatopaste, D= Plum tomato paste.

Table 2: Effect of storage period on the microbial load of the various tomato pastes

Samples	Period	Bacteria	Fungi
	Days	(cfu/mL)	(cfu/mL)
A		8.50± 0.07 ^a	NG
B	0	6.00 ± 0.00 ^c	NG
C		2.50 ± 0.07 ^d	NG
D		7.50 ± 0.07 ^b	NG
A		8.15 ± 0.07 ^a	NG
B	14	7.10 ± 0.14 ^b	NG
C		4.05 ± 0.07 ^d	NG
D		6.05 ± 0.07 ^c	NG
A		8.55 ± 0.00 ^b	1.15 ± 0.07 ^a
B	28	9.15 ± 0.07 ^a	NG

C		4.45 ± 0.07 ^d	NG
D		7.55 ± 0.00 ^c	NG
A		13.30 ± 0.00 ^a	1.55 ± 0.07 ^a
B	42	10.65 ± 0.07 ^b	NG
C		5.15 ± 0.07 ^d	1.25 ± 0.07 ^c
D		8.90 ± 0.00 ^c	NG

Mean with the same superscript in the same column are not significantly different at ($p < 0.05$). NG= No growth, A= UTC tomato paste, B= Cherry tomato paste, C= Beefsteak tomato paste, D= Plum tomato paste,

CONCLUSION

In recent years hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow short duration crop like vegetables round the year in very limited spaces with low labour, so hydroponics can play a great contribution in area with limitation of soil and water and for the poorer and landless people. The results showed that tomato paste can be produced from varieties of hydroponics tomato as they all contain moisture, protein, ash and fat and sample C has a comparative advantage over samples A, B and D in microbial analysis as it contained the lowest count of microbes and it will stay longer maintaining its quality. Further work should be carried out on the safety accumulations of metals and generally the nutritional advantages compared with the conventional products.

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MICROBIOLOGICAL QUALITY OF FRESHLY PREPARED SUGARCANE JUICE TREATED WITH HEAT AND NATURAL PRESERVATIVES

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Abstract

Sugarcane juice was produced with different treatments applied (addition of ginger and lemon, and heat treatment). To evaluate the microbial safety of the treated juices, enumeration and identification of microbial species were carried out using standard methods. Results of microbiological analyses revealed significant decrease in the total plate, total fungal, and Lactic acid bacteria counts with addition of ginger and lemon with pasteurization, with counts decreasing from 4.11 log CFU/ml to 3.33 log CFU/ml for total bacterial count. No *Bacillus cereus* growth was observed. pH values of the fresh juice ranged between 5.50 and 4.00 depending on the treatment. Bacteria identified from the various juice samples include *Klebsiella*spp, *Enterococcus*spp, *Micrococcus*spp, *Pseudomonas aeruginosa*, while fungi include *Saccharomyces cerevisiae*, *Candida albicans*, *Debaromyces*spp and *Aspergillusniger* with *Saccharomyces*spp having the highest population. Although the microbial load was within acceptable limits, a safer sugarcane juice can be produced with combination of ginger and lemon addition and pasteurization.

Keywords: Sugarcane juice, Natural preservatives, Microbial safety, Pasteurisation

Introduction

Sugarcane (*Saccharumofficinarum*) is a perennial grass crop whose stem grows tall into a cane stalk (FAO, 2020) with thick fibrous stem and sweet juice (Singhet *al.*, 2014). It is a major agricultural and industrial crop due to its economic and medicinal value. It is mostly consumed raw in Nigeria by chewing as chewing the cane accounts for 55 – 65% of the total cane production.

Sugarcane juice is becoming increasingly popular in Nigeriawith the increasing demand for healthy and natural drinks (devoid of chemical additives). Sugarcane juice is the sweet and refreshing ready-to-drink product (Kaavyaet *al.*, 2019) obtained after sugarcane is squeezed or crushed. It is consumed as a beverage (Ramachandranet *al.*, 2017) and can serve as a sweetener, liquid base for smoothies, processed into sugar and for syrup production (Sangeetaet *al.*, 2013).

According to Nishadet *al.* (2017) and Mwambete and Mpenda (2019), sugarcane juice has high water but also contains natural sugars, specific minerals, amino acids, vitamins, phosphatides, organic acids, and starch. It also contains a good amount of antioxidants, polyphenols,

phytonutrients, and other functional nutrients that promote good health and prevent several ailments (Panigrahi *et al.*, 2021), and has a low glycaemic index of 30-40 (Khare *et al.*, 2012).

Due to its high water activity and sugar content, sugarcane juice has been reported to be associated with several microorganisms. According to earlier research, sources of microbial contamination in the juice include unhygienic handling, the raw sugarcane stem, inadequate cleaning of the sugarcane press, knives, contact surfaces, vendors hands, water and airborne contamination (Yasire *et al.*, 2020), which may result in infections such as typhoid, abdominal cramps and diarrhoea. This implies that sugarcane juices produced without additional treatments can be a possible source of foodborne outbreak.

Natural preservatives such as ginger and lemon have been applied in food processing to retard or halt microbial activity in foods including sugarcane juice (Ramachandran *et al.*, 2017). This study seeks to evaluate the microbial safety of fresh sugarcane juice produced with addition of natural preservatives and heat treatment.

Materials and Methods

Raw material procurement

Sugarcane stalks of purple variety were purchased from a local market in Makurdi, Benue State, Nigeria. Fresh Ginger rhizomes and lemon fruits were purchased from Wadata market, Makurdi, Nigeria. All these were transported to the food-processing laboratory at the University of Agriculture, Makurdi for processing into sugarcane juice.

Sugarcane juice production

The sugarcane stalks were cleaned and scrapped using a sharp knife to remove their outer skin, soil and dirt. The stalks were then cut into about 20 - 30 inches for easy processing. The sugarcane was washed and allowed to drain in a basket. The ginger and lemon were also washed and allowed to drain. These were then weighed according to the recipe for juice sample preparation. Sugarcane juice was extracted using an electric 3-roller sugarcane crusher manufactured by Tubobiz. Three sugarcane juice samples were produced with application of hurdles as follows:

- a) Raw /untreated sugarcane juice (R),
- b) Raw sugarcane juice with the addition of lemon and ginger (O) and
- c) Raw sugarcane juice with the addition of lemon and ginger and pasteurized (G).

Microbiological analysis

Enumeration and isolation of microorganisms from sugarcane juice

The samples of sugarcane juice were subjected to the following microbiological tests: total plate count (TPC), yeast and moulds count, lactic acid bacteria (LAB) count, and *Bacillus cereus* count using the pour plate technique. Serial dilutions of the sugarcane juice samples were plated in duplicates onto suitable growth media and incubated at 37°C for 24 h for

bacteria and 5 days for fungi. After the incubation period, plates were observed for growth and colonies were counted and recorded. The culture media used were plate count agar for total plate count, MacConkey Agar for *Bacillus cereus* count, Potato Dextrose Agar for fungicount and deManRogosa Sharpe agar for lactic acid bacteria count. Each of the media was prepared according to the manufacturer's instructions. The procedures used were in accordance with the methodology described in the Compendium of Methods for the Microbiological Examination of Foods (APHA, 2001).

Identification of microorganisms from sugarcane juice

Predominant microbes on the plates were isolated and plated on several selective and differential media for identification using morphological and cultural characteristics, Gram stain, and Lactophenolcotton blue stain for fungi. They were then subjected to various biochemical tests including Indole, Vogues Proskauer and Methyl red test, Oxidase, Catalase, motility test, citrate test, nitrate reduction, and hydrogen sulphide production. Results were interpreted using Bergeys Manual (Holt, 1984).

pH determination

A pH meter analyser, pHep (a registered trademark of Hanna Instruments) was used in the measurement of pH values of the sugarcane juice samples. The samples for analysis were poured into a clean beaker with the pH meter inserted into it, and the reading recorded.

Statistical analysis

Data obtained from the study were subjected to analysis of variance (ANOVA) using Genstat Statistical software, version 17.1.

Results and Discussion

Results of the microbial count of fresh sugarcane juice processed with addition of ginger and lemon and heat treatment is presented on Table 1. It reveals a high microbial load in the raw sample (R). This is not surprising since hygiene standards are not usually maintained during harvest and transportation from the field to the point of extraction. Ramachandran *et al.* (2017) had made a similar report. Also, sugarcane attracts flies which can be a source of increased contamination during scrapping of the sugarcane in the market before extraction.

A significant decrease in microbial load was observed with application of the treatments to the sugarcane juice. The total plate count and lactic acid bacteria count decreased from 4.11 log CFU/ml and 3.43 log CFU/ml in the untreated juice (sample R) to 3.33 log CFU/ml and 2.62 log CFU/ml in sample G immediately after processing.

Table 2 presents the pH of sugarcane juice produced with addition of ginger and lemon, and pasteurization. The pH of the juice samples ranged from 4.0 to 5.5 immediately after production (0h) depending on the treatment applied to the juice, and decreased to pH 3.85

after 24h at room temperature. Low pH of fruit juices limits the number and the type of bacteria that can grow at that pH (Prescott *et al.*, 2002).

Table 1: Microbial Count of Fresh Sugarcane Juice processed with addition of ginger and lemon and heat.

Sugarcane juice sample	Microbial count (log CFU/ml)					
	Total plate count		Total fungal count		Lactic acid bacteria count	
	0h	24h	0h	24h	0h	24h
R	4.11 ^a ±1.22	5.09 ^a ±0.87	4.11 ^a ±0.96	5.75 ^a ±0.39	3.43 ^a ±0.54	4.66 ^a ±2.42
O	4.00 ^a ±0.76	4.85 ^b ±0.21	4.14 ^a ±0.94	4.73 ^{ab} ±0.51	3.85 ^a ±0.49	4.33 ^a ±0.41
G	3.33 ^b ±0.39	3.45 ^c ±0.21	3.07 ^a ±0.32	4.22 ^b ±0.28	2.62 ^b ±0.11	2.85 ^b ±0.86

Values are means ± standard deviations of duplicate determinations. Means in the same column with different superscripts are significantly (p<0.05) different.

Key: R-raw sugarcane juice, O- juice with addition of lemon and ginger, G- juice with addition of lemon and ginger and pasteurized.

Table2: pH values of Fresh Sugarcane Juice processed with addition of ginger and lemon and heat.

Sugarcane juice	pH (0h)	pH (24h)
R	5.50 ^a ±0.00	3.85 ^b ±0.07
O	4.00 ^b ±0.07	3.90 ^b ±0.00
G	4.00 ^b ±0.14	4.00 ^a ±0.07

Values are means ± standard deviations of duplicate determinations. Means in the same column with different superscripts are significantly (p<0.05) different.

Key: R-raw sugarcane juice, O- juice with addition of lemon and ginger, G- juice with addition of lemon and ginger and pasteurized.

Conclusion

It can be concluded that the microbiological quality of raw sugarcane juice without any treatment is poor and will require other processes including mild heat treatment to be undertaken to ensure its safety. With addition of ginger and lemon, sugarcane juice should still not be left at ambient temperature for several hours to prevent proliferation of microbes.

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MICROBIAL SHELF LIFE PREDICTION OF PEARL MILLET SOURDOUGH BREAD

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Abstract

The use of gluten-free flour in the production of sourdough bread is on the increase due to its culinary, economic and health benefits. This study predicted the microbial shelf life of stored pearl millet sourdough bread. Pearl millet flour was naturally fermented for 72 h to obtain sourdough. Sourdough bread was produced from pearl millet flour and sourdough while the control bread was produced from pearl millet flour and yeast, packaged in low density polyethylene (LDPE) and aluminium foil paper and stored at -5, 4, 6, 28 and 37 °C. The predicted fungi parameters ranged from -0.64-0.51 for initial cell concentration, 8.42-17.83 for final cell concentration, 0.92-1.00 for coefficient of determination, 0.02-0.16 for maximum specific growth rate, 14.44-21.82 for lag time and 0.38-0.96 for root mean square error. The predicted shelf life of the sourdough bread and control bread stored in both packaging materials at different temperatures included values from 26.7-463.5 h and 22.8-119.3 h. In conclusion, pearl millet sourdough bread stored in aluminium foil at -5 °C had the highest shelf life value of 463.5 h.

Keywords: Sourdough bread, Pearl millet, Fermentation, Microbial Shelf life, Predictive model

Introduction

Sourdough is a dough made from the fermentation of flour and water using naturally occurring yeast and lactic acid bacteria (LAB) and is used as a leavening agent in the production of bakery products (Siepmann *et al.*, 2018). Sourdough technology is a traditional process of bread production with a high nutraceutical factor such as minerals, vitamins and antioxidant and helps to extend the shelf life due to beneficial interaction of LAB and yeast and their biochemical reactions (Sakandari *et al.*, 2018). Sourdough bread is not only produced from wheat flour but also from other cereal flours such as pearl millet (Gobbetti *et al.*, 2019). Predictive model is a mathematical tool used for describing and explaining the microbial growth, their spread or activity in foods, fermentation processes and other applications as well as shelf life of foods (Esseri *et al.*, 2015). In bakery industry, spoilage of products is majorly by

moulds and hence prediction of fungal growth in bread is scarce in literature. This study was aimed at predicting the microbial shelf life of stored pearl millet sourdough bread.

Materials and Method

Materials

Pearl millet grains was purchased from Kuto market in Abeokuta, Ogun State, Nigeria. Packaging materials (LDPE and aluminium foil) were also purchased from kuto market in Abeokuta, Ogun State, Nigeria

Methods

Sourdough obtained from naturally fermented pearl millet flour for 72 h was mixed with unfermented pearl millet flour to produce sourdough bread in the ratio (1:2). The control was produced from a mixture of unfermented pearl millet flour and yeast. The bread samples were packaged in LDPE and aluminium foil and stored at -5, 4, 6, 28 and 37 °C for 2 weeks. Data generated from the total fungal count (TFC) during storage were fitted to predict the shelf life of the pearl millet sourdough bread. Three replicate samples from each storage temperatures were collected for analysis on days 0, 1, 2, 3, 7 and 14. TFC were analyzed and expressed in Log CFU g⁻¹ and data was used for primary predictive modelling using the Baranyi and Roberts model, ComBase, DMFit version 3.5 (Institute of Food Research, Norwich, UK, <http://www.ComBase.cc>) (Mwoveet *al.*, 2017). The Baranyi model (Baranyi and Roberts, 1994), is represented by equation 1

$$\ln(N(t)) = N_o + \mu_{max}A(t) - \ln\left(1 + \frac{e^{\mu_{max}A(t)} - 1}{e^{N_{max} - N_o}}\right) \quad (1)$$

$$A(t) = t + \frac{1}{\mu_{max}} \ln(e^{\mu_{max}t} + e^{-\mu_{max}\lambda} + e^{-\mu_{max}(t+\lambda)}) \quad (2)$$

Where $\ln(N(t))$ is the log of cell concentration at time t (h) (CFU g⁻¹), (N_o) is the log of initial cell concentration (CFU g⁻¹), μ_{max} is the exponential growth rate (log₁₀ (CFU h⁻¹), $\ln(N_{max})$ is the log of final cell concentration, λ is the lag time and $A(t)$ is as shown above (equation 2). The square root of the maximum specific growth rate (μ_{max}) generated from the primary model for each specific spoilage organism (SSO) were plotted against temperature using the Ratkowsky square-root model (Ratkowsky *et al.*, 1983). From the graph, the shelf life (Minimal spoilage level) of the food with emphasis on the SSO and TFC were predicted.

$$\sqrt{\mu_{max}} = c(T - T_{min}) \quad (3)$$

where T_{min} is the minimum temperature at which growth is possible, T is the experimental temperature, and c is a regression coefficient.

Results and Discussion

Table 1 shows the result of the predicted fungal growth parameters of the bread samples stored in LDPE and aluminium foil paper at different storage period. Pearl millet sourdough bread and control stored at -5 °C had no fungal growth parameters as no mould growth were observed in the bread during the period of storage. Bread samples without values of lag phase and final cell concentration can be attributed to few sampling points gotten from the TFC as some results of the TFC were too numerous to be counted. Increase in temperature from 4

°C to 37 °C nearly doubled the rate of growth of microorganism as predicted by the Baranyi and Roberts model.

Table 2 shows the predicted shelf life of pearl millet sourdough bread and control bread stored in low density polyethylene and aluminium foil paper at different storage temperatures. The values of the predicted growth rate ranged from 0.0086-0.1758, shelf life ranged from 22.8 to 463.5 h. Shelf life taken was the time required to reach 10^4 according to WHO 1994 standard which is the maximum permissible limits of fungal count in bread. Increase in the storage temperature from -5 °C to 37 °C resulted to an increase in the growth rate of fungi and a decrease in the shelf life of the bread samples. The predicted shelf life of the sourdough bread and control bread stored in both packaging materials at the different temperatures ranged from 26.7-463.5 h and 22.8-119.3 h. Proper packaging and storage of sourdough bread in appropriate conditions is therefore an important necessity if acceptability of the product is to be maintained.

Table 1: Predicted fungal growth parameters at different storage temperature of pearl millet sourdough bread

Samples	Temp (°C)	N_0 (LogCFU g^{-1})	N_{max} (LogCFU g^{-1})	R^2	μ_{max} (CFU $g^{-1} h^{-1}$)	λ (h)	RMSE
AT	6	-0.214	8.589	0.960	0.0780	15.367	0.637
BS		-0.209	8.424	0.958	0.0733	14.441	0.645
CR		0.514	17.827	0.904	0.0240	-	0.911
DQ		0.439	-	0.918	0.0238	-	0.828
EP	28	-0.632	-	0.9991	0.1579	-	0.949
FO		-0.607	-	0.9980	0.1517	-	0.911
GN		-0.0588	-	1.0000	0.1469	-	0.881
HM		-0.581	-	1.0000	0.1453	-	0.872
IL	37	-0.639	-	0.9999	0.1597	-	0.958
JK		-0.625	-	0.9997	0.1562	-	0.938
KJ		-0.165	-	0.9710	0.1200	21.261	0.423
LI		-0.160	-	0.9760	0.1190	21.819	0.375
MH	4	0.123	8.825	0.9500	0.0409	-	0.730
NG		0.117	8.825	0.9510	0.0402	-	0.717
OF		0.400	-	0.9210	0.0240	-	0.819
PE		0.364	-	0.9200	0.0239	-	0.820
QD	-5	-	-	-	-	-	-
RC		-	-	-	-	-	-
SB		-	-	-	-	-	-
TA		-	-	-	-	-	-

AT- control bread stored in polyethylene at 6 °C; BS- control bread stored in foil at 6 °C; CR- sourdough bread stored in polyethylene at 6 °C; DQ- sourdough bread stored in foil at 6 °C; EP- control bread stored in polyethylene at 28 °C; FO- control bread stored in foil at 28 °C; GN- sourdough bread stored in polyethylene at 28 °C; HM- sourdough bread stored in foil at 28 °C; IL- control bread stored in polyethylene at 37 °C; JK- control bread stored in foil at 37 °C; KJ- sourdough bread stored in polyethylene at 37 °C; LI- sourdough bread stored in foil at 37 °C; MH- control bread stored in polyethylene at 4 °C; NG- control bread stored in foil at 4

°C; OF- sourdough bread stored in polyethylene at 4 °C; PE- sourdough bread stored in foil at 4 °C; QD- control bread stored in polyethylene at -5 °C; RC- control bread stored in foil at -5 °C; SB- sourdough bread stored in polyethylene at -5 °C; TA- sourdough bread stored in foil at -5 °C; N_0 - Initial cell concentration; N_{max} - final cell concentration; R^2 -coefficient of determination; μ_{max} - maximum growth rate; λ - lag time; RMSE- Root mean square error.

Table 2: Predicted shelf life of pearl millet sourdough bread

Samples	Temp (°C)	Predicted growth rate (Log CFU h ⁻¹)	Predicted shelf life (h)
AT	6	0.0619	64.6
BS		0.0593	67.4
CR		0.0290	137.9
DQ		0.0289	138.6
EP	28	0.1368	29.3
FO		0.1329	30.1
GN		0.1052	38.0
HM		0.1049	38.1
IL	37	0.1758	22.8
JK		0.1715	23.3
KJ		0.1500	26.7
LI		0.1497	26.7
MH	4	0.0565	70.7
NG		0.0541	73.9
OF		0.0244	163.7
PE		0.0243	164.6
QD	-5	0.0355	112.8
RC		0.0335	119.3
SB		0.0087	459.5
TA		0.0086	463.5

AT- control bread stored in polyethylene at 6 °C; BS- control bread stored in foil at 6 °C; CR- sourdough bread stored in polyethylene at 6 °C; DQ- sourdough bread stored in foil at 6 °C; EP- control bread stored in polyethylene at 28 °C; FO- control bread stored in foil at 28 °C; GN- sourdough bread stored in polyethylene at 28 °C; HM- sourdough bread stored in foil at 28 °C; IL- control bread stored in polyethylene at 37 °C; JK- control bread stored in foil at 37 °C; KJ- sourdough bread stored in polyethylene at 37 °C; LI- sourdough bread stored in foil at 37 °C; MH- control bread stored in polyethylene at 4 °C; NG- control bread stored in foil at 4 °C; OF- sourdough bread stored in polyethylene at 4 °C; PE- sourdough bread stored in foil at 4 °C; QD- control bread stored in polyethylene at -5 °C; RC- control bread stored in foil at -5 °C; SB- sourdough bread stored in polyethylene at -5 °C; TA- sourdough bread stored in foil at -5 °C

Conclusion

Acceptable bread was produced without the inclusion of preservatives from 100 % pearl millet flour. Pearl millet sourdough bread stored at -5 °C had the highest shelf life of 463.5 h while pearl millet yeast bread stored at 37 °C had the lowest shelf life of 26.7 h. In view of this,

LDPE can be used for packaging and storage of sourdough bread as it is cheaper, flexible, strong, easy to seal, and is resistant to moisture.

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PRELIMINARY EVALUATION OF MICROBIAL AND PHYSICOCHEMICAL QUALITY OF SOY-KUNUZAKINON-ALCOHOLIC BEVERAGE

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ABSTRACT

In this study, the microbial count of soy kunuzaki produced with and without HACCP protocols as well as commercial kunuzaki were evaluated. Samples of soybeans was obtained from NCRI Badeggi while millet, ginger, black pepper, clove, cinnamon and commercial kunuzaki were purchased from Bosso market in Minna. Soy Kunu-zaki was produced according to the method described by Anounye while the total titratable acid, bacterial, fungal and coliform counts were analysed according to standard methods. Preliminary result shows that bacterial count commercial kunuzaki was $5.6 \times 10^3 \pm 0.5$ cfu/ml while the Soy kunuzaki with and without HACCP were $1.2 \times 10^3 \pm 0.5$ cfu/ml and $2.4 \times 10^3 \pm 0.5$ cfu/ml respectively. The coliform count in commercial kunuzaki was 3.0×10^0 cfu/100ml compared to 2.0×10^0 cfu/100ml obtained for soy kunuzaki produced with and without HACCP protocols. Only commercial KunuZaki had fungi growth (1.0×10^3 cfu/ml). Titratable acids of the commercial kunuzaki was 1.8×10^{-1} g/L as against 5.9×10^{-2} g/L obtained for the soy kunuzaki samples. Total soluble solid were 8.04×10^1 %, 7.93×10^1 % and 7.91×10^1 % for commercial kunuzaki, soy kunuzaki with and without HACCP protocols respectively. This study concludes that soy kunuzaki produced using HACCP protocols had less microbial contamination compared to the other samples.

Keywords: HACCP, soy-kunuzaki, Cereals, non-alcoholic beverages

INTRODUCTION

Beverages are liquid drink prepared for human consumption (Azamet *et al.*, 2021). Beverages represent a large proportion of our daily calorie and nutrient intake. They are however classified into alcoholic and non-alcoholic beverages. Non-alcoholic beverages are potable drinks which have thirst-quenching, refreshing, stimulating and nourishing qualities (Bolarinwa *et al.*, 2018). They provide energy, hydrate the body and strengthen health by preventing nutrition-related deficiencies. Among the prominent non-alcoholic Nigerian beverage is kunuzaki produced from fermented cereal grain. A method of fortifying kunu-zaki with whole soybean was developed to boost its nutritional value and reduce the incidence of malnutrition in Nigeria. Soy-kunuzaki is produced from cereal - soybean base (Anounye *et al.*, 1997). Both kunu-zaki and soykunuZaki are prone to microbial spoilage if not adequately stored at refrigeration temperature and could act as important medium for the transmission of pathogenic microorganisms. According to Umaru *et al.* (2014), local drinks such as kunu could act as vehicles for zoonotic and food-borne infections including Staphylococcosis, Salmonellosis, Brucellosis, Tuberculosis, Shigellosis and Listeriosis. Funtua and Agha (2016) reported *Aspergillus* and *Penicillium* species in kunuzaki. They are both toxigenic fungi including

the *Fusarium* species. *Fusarium* is commonly isolated from cereals, and it is the most prevalent toxin-producing fungi (Hietaniemi *et al.*, 2016). Mycotoxins are toxic secondary metabolites of fungal origin and contaminate agricultural commodities before or under post-harvest conditions. They are fungal secondary metabolites that may develop in any food or feedstuff during the growing season, at harvest time, or during processing or storage, depending on the environment and method of handling (Abasset *et al.*, 2022). It can also develop in beverages as reported by Mhlango *et al.* (2020). The secondary metabolites produced by fungi have been increasingly associated with health problems, and there is a global concern about the potential effects of these compounds for humans, because some of them may be genotoxic and carcinogenic, (Franz and Welle, 2020). The objective of this study was to establish the safety of soy kunu-zaki prepared following the Hazard Analysis Critical Control Point (**HACCP**) protocols.

Materials and Methods

Sample Collection

Samples of soybeans (*Glycine max*) were obtained from National Cereals Research Institute (NCRI), Badeggi, Bida Niger state while millet (*Pennisetum typhodeum*) ginger (*Zingiber officinale*), Black pepper (*Piper spp*), Clove (*Eugenia caryophyllata*) and Cinnamon (*Xylopia aethiopica*) were purchased from Bosso local market, Niger State.

Preparation of Soy KunuZaki

Soy Kunu-zaki was produced as described by Anounye *et al.* (1997).

Soy KunuZaki with HACCP Protocols

Samples of millet (*Pennisetum typhodeum*), clove (*Eugenia caryophyllata*), ginger (*Zingiber officinale*), black pepper (*Piper spp*), soybeans (*Glycine max*), and cinnamon (*Xylopia aethiopica*) were taken out, carefully cleaned, and sorted, with any damaged grains being eliminated. The millet samples were steeped in potable water overnight, then washed and blended with the soybean samples in a 1:1 ratio along with ginger, black pepper, cloves, and cinnamon. The mixture was then wet milled and cooked at 85°C for 15min, then allowed to sediment before being filtered using a muslin cloth. The soybean samples were blanched at 100°C for 25min, soaked overnight, and washed with potable water.

Soy Kunu Zaki without HACCP Protocols

Samples of millet (*Pennisetum typhodeum*), clove (*Eugenia caryophyllata*), cinnamon (*Xylopia aethiopica*), ginger (*Zingiber officinale*), black pepper (*Piper spp.*), and soybeans (*Glycine max*) were taken out. The samples of soybeans were soaked in water overnight and washed, while the samples of millet were steeped in water overnight, washed, and blended in a 1:1 ratio with ginger, black pepper, cloves, and cinnamon. The mixture was then wet milled, cooked at 85°C for 40 minutes, and allowed to sediment before being filtered through a muslin cloth and sugar syrup was added afterward.

Physicochemical and Microbial Analysis

The total titratable acid and microbial (bacterial, fungal and total coliform counts) analysis of the soy kunuzaki beverage were carried out according to the methods described in AOAC (2019).

Method of Data Analysis

The data was analysed using the Analysis of Variance (ANOVA) feature of the Statistical Package for Social Sciences (SPSS) version 26.

Results and Discussion

Preliminary result of the microbial counts of the samples of kunu used in this research are shown in Table 1. The results revealed that commercial kunuzaki had significantly higher ($p \leq 0.05$) bacteria growth of $5.6 \times 10^3 \pm 0.5$ cfu/ml, which could be due to poor water quality or unhygienic processing environment while the Soy kunuzaki with HACCP and soykunuzaki without HACCP were $1.2 \times 10^3 \pm 0.5$ cfu/ml and $2.4 \times 10^3 \pm 0.5$ cfu/ml respectively. As expected, the HACCP protocol produced soy kunuzaki sample with significantly ($p \leq 0.05$) reduced bacterial count. It was virtually free of fungi while the coliform count of 2.0×10^0 cfu/ml was within the acceptable range for bacteria. This was also observed for bacterial count which the acceptable limit is (10–100 cfu/ml) according to Afreen *et al.* (2019). Also, coliform count in commercial kunuzaki was significantly higher ($p \leq 0.05$) (3.0×10^0 cfu/ml) when compared to soykunuzaki with HACCP and soykunuzaki without HACCP, both of which had coliform count of 2.0×10^0 cfu/ml at $p \leq 0.05$. The presence of coliform bacteria in the all kunu samples may be due to the use of tap water because coliform bacteria had been reported to be associated with tap water (Amusa and Ashaye, 2009). Only commercial KunuZaki without HACCP had fungi growth (1.0×10^3 cfu/ml) which may be due to possible fungi contamination of the millet sample used, since most fungi associated with drinks are storage micro-flora of cereals. There was no growth in soykunuzaki without HACCP and SoyKunuZaki with HACCP. This may be due to the use of fungi-free millet samples, this conformed to the study of Amusa and Ashaye (2009). Titratable acids of the commercial kunuzaki was also significantly higher ($p \leq 0.05$) (1.8×10^{-1} g/L) when compared to 5.9×10^{-2} g/L. **apeace** obtained for samples soykunuzaki with and without HACCP. Total Soluble Solid were 8.04×10^1 %, 7.93×10^1 % and 7.91×10^1 % for commercial kunuzaki, Soykunuzaki without HACCP and Soykunuzaki with HACCP respectively. The implication of these results is that Soy kunuzaki produced with HACCP procedure would be safer than any of the other samples. It is therefore recommended that local production of such cereal-based non-alcoholic beverages should be prepared using HACCP protocols.

Table 1: Microbial and Physiochemical Analysis of KunuZaki Prepared Using Different Methods

Samples	SoyKunuZaki with HACCP	SoyKunuZaki without HACCP	Commercial KunuZaki
Bacteria cfu/ml	$1.2 \times 10^3 \pm 0.5^a$	$2.4 \times 10^3 \pm 0.5^b$	$5.6 \times 10^3 \pm 0.5^c$
Fungi cfu/ml	$0.0 \times 10^3 \pm 0.0^a$	$0.0 \times 10^3 \pm 0.0^a$	$1.0 \times 10^3 \pm 0.0^b$
Coliform cfu/100ml	$2.0 \times 10^0 \pm 0.0^a$	$2.0 \times 10^0 \pm 0.0^a$	$3.0 \times 10^0 \pm 0.0^b$
Total Titrable Acid (g/L)	$5.9 \times 10^{-2} \pm 0.0^a$	$5.9 \times 10^{-2} \pm 0.0^a$	$1.8 \times 10^{-1} \pm 0.0^b$
Total Soluble Solid %	$7.91 \times 10^1 \pm 0.0^a$	$7.93 \times 10^1 \pm 0.0^b$	$8.04 \times 10^1 \pm 0.0^c$

All values were reported as mean plus/minus standard error of mean (SEM). Values along the row with the same alphabetic superscript are not significant while those with different alphabetic superscript are significant at $p \leq 0.05$.

Conclusion

In conclusion, soy kunuzaki produced using HACCP protocols had lower microbial counts compared to the other samples. Hence, it is recommended that local production of such cereal-based non-alcoholic beverages be prepared using HACCP protocols.

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CHAPTER 7 NUTRITION

QUALITY EVALUATION OF DEHULLED SORGHUM AND ORANGE-FLESHED SWEET POTATO (OFSP) FLOUR BLENDS FOR COMPLEMENTARY FOOD APPLICATION

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Abstract

Complementary food was produced from dehulled sorghum and orange fleshed sweet potato (OFSP) flour blends. Five (5) different formulations were made for the production of the complementary food in the following ratio 100:0, 90:10, 80:20, 70:30, 60:40%, for dehulled sorghum and OFSP flours respectively. The result of proximate composition of flour blends were; protein, fat, fibre, ash, moisture and carbohydrate which ranges from 12.35 -17.76%, 3.75 -5.05%, 0.43 -0.41%, 6.52 -6.85%, 9.92 -10.19%, 60.01-66.26% respectively. The functional properties assay of the flour blends were bulk density, viscosity, gelation capacity, water absorption, gelatinization temperature and emulsification capacity which ranges from 0.48 -0.73 g/ml, 385.62 -486.02°C, 8.15 -10.85%, 90.66 - 80.61, 70.15 - 66.15°C and 17.85 - 22.05% respectively. The sensory assessment results of the complementary porridges were acceptable as judged by the panelist though there are significant differences ($P \leq 0.05$) in some parameters but sample DSPF₃ (Blends of 70% Dehulled Sorghum Flour and 30% OFSP Flour) was the most preferred.

Keywords: Sorghum, Orange-flesh -sweet-potatoes, Complementary foods, Flour blends,

1. Introduction

Complementary foods are foods given to infants in addition to breast milk when breast milk nutrients become inadequate for their energy and growth needs (Onyekwere, 2007). Complementary foods are defined by the World Health Organization (WHO) as any food or liquid other than breast milk. However, since many infants receive human milk substitutes from the first weeks of life, other authorities have suggested that the term complementary foods should be applied to food and liquids other than breast milk (WHO, 2004).

Complementary foods are required during the second part of the first year of life (that is 2-3 times daily) between the ages of 6-8 months and 2-4 times daily between the ages of nine and eleven (9-11) months). This is for both nutritional and developmental reasons and to enable the transition from milk feeding to family foods. From a nutritional point of view, the ability of breast milk to continue to meet macro and micro nutrients requirement becomes limited, whereas from a developmental perspective infant develops the ability to chew and start to show an interest in foods other than breast milk (WHO, 2004).

Sorghum is one of the three most common grain used in traditional complementary foods (Ebunoluwa *et al*; 2017). Sorghum is related to sugar cane and to millet and is called “great

millet” in some areas of west Africa , it is an important staple food of the upland, drier part of Africa and India where no other cereals can successfully be raised. Sorghum is able to grow in soils that are quite poorly nourished, with an unreliable water supply (Dykes and Rooney, 2006).

Different varieties of sorghums range in colour from white and pale yellow to deep red, purple and brown. Sorghum is the third largest crop produced in Australia. It is produced in northern growing region of Australia with an average annual production of over 2 million tons (Dykes and Rooney 2006).Sorghum is rich in carbohydrates, (mainly starch), moderate protein content low in lysine, low in fat, most of which saturated, a good source of dietary fiber, high in potassium and low in sodium, gluten free, contains B- group vitamin such as thiamin, riboflavin, vitamin B6 (pyridoxine), foliate and panthenic acid, contains vitamin E. It contains minerals such as iron, zinc, magnesium, phosphorus and selenium (depending on the soil content of selenium), contains small amount of copper, magnesium and calcium, and phytochemicals including lignans, phenol acids, phytic acids, plant sterols and saponins (FAO, 2006).

Sorghum grains are recently being used in some multi-grain products, including breakfast cereals and bars or can be boiled whole and eaten like rice. It is also used in a variety of traditional foods world-wide including breads, porridges, steamed products, boiled products, beverages and snacks foods (Popped sorghum) (Ebunoluwa *et al*, 2017).

Orange fleshed sweet potato (OFSP), when coupled with community nutritional education, offer a promising solution by providing high level of vitamin A. But gathering the evidence needed to scale this solution did not come easily. One small boiled root of most OFSP varieties provides 55% of the recommended vitamin A for children and one medium root of energy, a number of B vitamins, several minerals (Phosphorus, potassium) and vitamin of C and K (Andrade *et al*, 2016).

This research work is aimed atproducing complementary food from dehulled sorghum and orange flesh sweet potato, to determine the physico chemical properties of the various blends of dehulled sorghum and orange fleshed-sweet potato (OFSP) flour, to carry out the sensory evaluation on the complementary food from the respective blends of dehulled sorghum and orange fleshed sweet potato (OFSP) flour.

2. Materials and Methods

2.1. Sample collection

Orange fleshed sweet potatoes tuber was purchased from an outlet of the Raw Material Research and Development Council, Abuja. Sorghum was obtained from KauraNamoda market, KauraNamodaLocal Government Area of Zamfara state. Other materials used such as weighing balance Mushin cloth, bowls, cabinet dryer (oven), trays (stainless steel), mechanical sieve, knife, milling machine, etc were obtained from the food processing workshop of the Department of Food Technology, Federal Polytechnic KauraNamoda, Zamfara State, Nigeria.

2.2 Sample preparations

The orange fleshed sweet potato roots were processed immediately on its arrival at the laboratory, the roots were washed, peeled and cut into tiny pieces manually, it was then dried

using cabinet dryer, milled using Accumax B&B-TC-1 Model milling machine, sieve using mechanized sieve, it was then cooled, packaged using polyethylene bag, and labeled accordingly (Avula, 2005).

Also Sorghum flour was produced using the method described by Ihekoronye&Uzomah(2011). The sorghum was sorted, cleaned, washed, and dehulled, it was then dried after which it was milled using the milling machine and then it was sieved. Dehulled sorghum flour obtained was packed in an air tight container then stored.

The complementary flour blends were formulated in 100: 0%, 90:10%, 80: 20%, 70: 30% and 60: 40% ratios of dehulled sorghum and orange fleshed sweet potatoes (OFSP) respectively.

2.3 Determination of proximate composition and functional properties

The proximate compositions (moisture, protein, ash, fibre and carbohydrate contents) of the flour blends were determined using the methods of Onwuka, 2018, also the functional properties (bulk density, viscosity, gelation capacity, gelatinization temperature, water absorption capacity and emulsification capacity) of the flour blends were determined as well using the methods prescribed by Onwuka, 2018.

2.4 Complementary food preparation

The various complementary food or porridge(s) were prepared according to the methods of Nzeagwu and Nwaejike (2008). 100g of each flour blends were homogenized with 300ml water. The slurry was heated slowly with constant stirring for 5 minutes. The porridges were kept separately in labeled thermos flasks (Master Chef, MC/F906 Model Nigeria) for sensory evaluation.

2.5 Sensory evaluation

Ten (10) minutes after preparation of the complementary food, sensory evaluation was carried out. Fifteen (15) semi-trained panelists who are familiar with the quality attributes of the complementary food, who were majorly mothers were recruited from staff and students of Federal Polytechnic, Kaura Namoda Zamfara state. Each panelist evaluated all the samples prepared from each treatment in one session, they were instructed to evaluate them based on colour, flavour, consistency and overall acceptability using the nine point Hedonic scale(Onwuka, 2018) samples were identify with code name and presented to the panelist.

2.6 Statistical analysis

The results obtained were all subjected to statistical analysis, which is one way ANOVA using the SPSS version 16.

3. Result and Discussion

Table 1 above shows the results of the proximate analysis of the dehulled sorghum and Orange Flesh Sweet flour blends for the complementary food. The protein, fat and ash increased with increase in OFSP flour inclusion, while the moisture and carbohydrate decreased with increased inclusion. The protein content of the flour blends ranges from 12.35% to 16.23% for DSF and DFSP₃ samples respectively, it also shows that there were significant differences ($P \leq 0.05$) between the proteins content of the various samples.

The ether extracts of the blends ranges from 3.75% for sample DSF to 5.05% for sample DFSP₄, the statistical evaluation shows that there were also significant differences ($P \leq 0.05$) among the ether extracts of the samples and the content also increased with increase in the addition of OFSP.

The crude fibre of the flour blends ranges from 0.41% to 0.45% for samples DFSP₄ and DFSP₃ respectively, the statistical analysis indicated that there were no significant differences ($P \leq 0.05$) in the fibre contents of samples DSF, DFSP₁ and DFSP₄, but there is with the rest two samples, which are not also significant difference from each other that is samples DFSP₂ and DFSP₃.

The ash content ranged from 6.52% to 6.85% for sample DSF and sample DFSP₄. It was also observed that the ash content of the flours increased slightly with increased addition of OFSP flour. There were no significant differences ($P \leq 0.05$) in the ash contents of the samples.

The moisture content of the blends was 9.85% for sample DSPF₂ (the least) and 10.20% for sample DSPF₁(highest). There were no significant difference ($P \leq 0.05$) between samples DSF & DSPF₁ which were both significantly different ($P \leq 0.05$) from other three samples DSPF₄, which is equally significantly difference ($P \leq 0.05$) from others.

The carbohydrate content of the blends ranged from 60.01% to 66.26% for samples DSPF₄ and DSF respectively; there were significant differences ($P \leq 0.05$) among all the samples of the flour blends.

Table 2 shows the result of the functional and sensory properties of the complementary flour blends from dehulled sorghum flour and OFSP flour. The bulk density, viscosity, gelation capacity and emulsification capacity increased with increased OFSP flour inclusion, while water absorption capacity and gelatinization temperature decreased. Samples were significantly different in all functional parameters evaluated except for gelatinization temperature. The bulk density which ranged 0.48g/m³ to 0.73g/m³, the increase in the values is due to the high fibre content of OFSP as confirmed by Elemoet *al*, (2011). There were significant differences ($P \leq 0.05$) among the samples.

Viscosity in the flour blends ranges from 385.62cP to 486.02cP. The values in blend correspond with the findings of Nzeagwu&Nwaejike, (2008);and it shows that there were significant differences ($P \leq 0.05$) among the samples.

Gelation capacity ranged 8.15%to 10.85%, for sample blends of DSPF₁ and DSPF₂ there were no significant difference($P \leq 0.05$) among them but they are significantly difference($P \leq 0.05$) from the rest three samples which are also significantly difference($P \leq 0.05$) from each other and the increase in the values could be due to the attributes of high protein content (FAO, 2006).

The water absorption capacity ranged 80.61 – 90.66%, the value decreases with OFSP inclusion this implies that the low water absorption capacity of the flour blend obtained will be desirable for making thinner gruel with high caloric density per-unit value (Ebunoluwa*et al*, 2017). The statistical analysis indicated that for samples DSPF₁ and DSPF₂ there were no

significant difference ($P \leq 0.05$) among them but they are significantly difference ($P \leq 0.05$) from other samples that are also difference from each other

Gelatinization Temperature values ranges 66.15°C – 70.15°C . The Gelatinization temperature is influenced by the structure of the starch polymers (Ebunoluwa *et al*, 2017). The statistical analysis shows that there were no significant differences ($P \leq 0.05$) in the gelatinization temperatures of the samples.

Emulsification capacity of the flour blends ranged from 17.85% to 22.05%, the statistical analysis shows that there were significant differences ($P \leq 0.05$) among the samples.

The results of the sensory evaluation of the complementary porridge that were shows there were no significant difference ($P \leq 0.05$) in the taste, consistency and flavor, but for the colour samples DSF, DSPF₁, and DSPF₂ shows no significant difference among themselves likewise samples DSPF₃ and DSPF₄. Also in the overall acceptability there were no significant differences ($P \leq 0.05$) in samples DSPF₁, DSPF₂, DSPF₃ and DSPF₄ but they are significantly difference ($P \leq 0.05$) from sample DSF. The result also showed that sample DSPF₃ (Blends of 70% Dehulled Sorghum Flour and 30% OFSP Flour) was the most preferred sample.

Table 1: Proximate composition (% , dry basis) of dehulled sorghum and orange fleshed sweet potato flour blends

Sample	Crude Protein	Ether extract	Crude fibre	Ash	Moisture	Carbohydrate
DSF	12.35 ^a ±0.02	3.75 ^a ±0.00	0.43 ^a ±0.01	6.52 ^a ±0.00	10.19 ^d ±0.01 ^d	66.26 ^e ±0.02
DSPF ₁	13.63 ^b ±0.02	3.87 ^b ±0.01	0.43 ^a ±0.01	6.55 ^a ±0.00	10.20 ^d ±0.00 ^d	65.29 ^d ±0.03
DSPF ₂	14.35 ^c ±0.01	3.95 ^c ±0.01	0.45 ^b ±0.00	6.60 ^a ±0.00	9.85 ^a ±0.00 ^a	64.78 ^c ±0.04
DSPF ₃	16.23 ^d ±0.01	4.53 ^d ±0.01	0.45 ^b ±0.01	6.72 ^a ±0.00	9.88 ^b ±0.00 ^b	62.22 ^b ±0.02
DSPF ₄	17.76 ^e ±0.01	5.05 ^e ±0.00	0.41 ^a ±0.01	6.85 ^a ±0.00	9.92 ^c ±0.00 ^c	60.01 ^a ±0.01

Values are means ± standard deviation. Means with different superscript within the same row are significantly different at 5% level of significance. Sample DSF: 100% Dehulled Sorghum Flour

DSPF₁: Blends of 90% Dehulled Sorghum Flour and 10% OFSP Flour

DSPF₂: Blends of 80% Dehulled Sorghum Flour and 20% OFSP Flour

DSPF₃: Blends of 70% Dehulled Sorghum Flour and 30% OFSP Flour

DSPF₄: Blends of 60% Dehulled Sorghum Flour and 40% OFSP Flour

Table 2: Functional and sensory properties of dehulled sorghum and orange fleshed sweet potato flour blends

Functional properties						
Sample	Bulk Density g/ml	Viscosity @ 29 °C	Gelation capacity %	Water absorption	Gelatinization Temp °C	Emulsification capacity %
DSF	0.48 ^a ±0.01	385.62 ^a ±0.01	8.15 ^a ±0.00	90.66 ^d ±0.00	70.15 ^a ±0.00	17.85 ^a ±0.00
DSPF ₁	0.55 ^b ±0.01	395.63 ^b ±0.01	9.65 ^b ±0.00	88.15 ^c ±0.01	67.85 ^a ±2.82	18.34 ^b ±0.00
DSPF ₂	0.62 ^c ±0.00	422.52 ^c ±0.00	9.82 ^b ±0.01	87.63 ^c ±0.01	69.30 ^a ±0.00	19.67 ^c ±0.01
DSPF ₃	0.65 ^d ±0.00	478.96 ^d ±0.01	10.15 ^c ±0.00	85.10 ^b ±0.00	69.00 ^a ±0.00	20.16 ^d ±0.01
DSPF ₄	0.73 ^e ±0.01	486.02 ^e ±0.01	10.85 ^d ±0.00	80.61 ^a ±0.01	66.15 ^a ±0.00	22.05 ^e ±0.01
Sensory evaluation						

	Taste	Consistency	Flavor	Colour	Overall acceptance
DSF	7.27 ^a	7.87 ^a	7.93 ^a	8.53 ^b	8.53 ^b
DSPF ₁	7.47 ^a	8.00 ^a	8.00 ^a	8.47 ^b	8.40 ^a
DSPF ₂	7.40 ^a	7.93 ^a	8.13 ^a	8.27 ^b	8.13 ^a
DSPF ₃	6.93 ^a	7.54 ^a	7.94 ^a	7.53 ^a	7.44 ^a
DSPF ₄	7.20 ^a	7.67 ^a	7.84 ^a	6.93 ^a	7.60 ^a

Value are means $\pm$ standard deviation. Means with different superscript within the same row are significantly different at 5% level. Sample codes are the same with those presented in Table 1.

4. Conclusions

This research work has shown that composite flour from flour blends of Dehulled Sorghum and Orange Sweet Potato could be used for complementary food production that will be well acceptable by the consumers. The complementary food from dehulled sorghum and orange fleshed sweet potato (OFSP) flour blends has increase nutrient of carbohydrate, fibre, fat, ash, and protein and starch digestibility. Thus, the flour blends will enhance the health, growth and wellbeing of infants. The use of complementary food from dehulled sorghum and orange fleshed sweet potato (OFSP) flour blends would promote production, value addition and diversification of utilization of the crops in Nigeria and other countries and this would create wealth and also enhance food security since both materials are domicile in Nigeria

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PRELIMINARY STUDY ON MILLET HUSK AS AN ENHANCER FOR BREAST MILK PRODUCTION

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ABSTRACT

Globally, lactation insufficiency continue to be of serious health concern, these compels researchers to dwell on finding more promising means to overcome this challenge. For this reason, this research investigated the effect of millet husk on blood Prolactin level of lactating albino rats with a view to suggesting alternative breast milk enhancers of plant origin. Samples of millet husk were collected from Wudil local government area of Kano State. The husks were processed and representative sample obtained for proximate analysis. The phytoconstituents were extracted and reconstituted at a concentration of 5%, 10% and 15%. The extracts were then fed to lactating mothers' of albino rats, after which blood plasma were analysed for Prolactin levels using ELISA. The result shows that the weight of the various groups (A, B, C and D) of the lactating mothers increase during the course of breast feeding while their Plasma Prolactin levels were observed to be not significantly different ($p > 0.05$) among the age groups. Therefore, it is recommended that further work should be carried out with a view to unveil other potentials of the plant product.

Key words: Millet husk, Prolactin, Lactating albino rats, Breast milk

INTRODUCTION

Millet husks are the by-product of the de-hulling of millet grains for human consumption. The millet species is usually unspecified and the husks may come from any of the major or minor millet species (FAO, 1995). Millet husk is gotten from the harvest of millet before it is been sold in the market (Agostini & Haschke, 2003) (McDonough, et al., 2000). Millet husks have been found to contain high amounts of silicon (5.7% Dry Matter), little protein (< 3% Dry Matter) and large amounts of fibre (ADF > 45% Dry Matter), including lignin (>11% Dry Matter) (Sale, 2009). Breastfeeding is the feeding of an infant or young child with breast milk directly from female human breasts via lactation. Experts recommend that children be breastfed within one hour of birth, exclusively breastfed for the first six months, and then breastfed until age two with age-appropriate, nutritionally adequate and safe complementary foods. Majority of lactating mothers complain of insufficient breast milk to cater for their babies; hence we aimed to investigate the effect of millet husk on blood Prolactin level of

lactating albino rats with a view to suggest alternative breast milk enhancers of plant origin. (Baker, 2003)

MATERIALS AND METHODS

Millet husk used in the experiment was collected from Wudil local government area of Kano State, Nigeria. The husk was chopped in to smaller sizes and grounded to powder form using pestle and mortar and then sieved. The processed husk was bagged, stored and representative sample obtained for proximate analysis. Forty gram of powdered husk was soaked into 400ml of distilled water and left for 72 hours then filtered. The extract was concentrated to 5%, 10% and 15% using water bath at 40°C (Sofowora, 1993). Lactating albino rats of different weights were obtained and isolated for the experiment. The extract was then fed to the lactating mothers ad-libitum, with the control group given water for four weeks. Blood plasma were collected from the mothers and analyzed for Prolactin levels using ELISA.

RESULTS AND DISCUSSION

The initial weight of lactating mothers; group A (186.67 ± 30.55), B (170.00 ± 45.83), C (196.67 ± 15.27) and D (180.00 ± 10.00) were observed to increase during the course of breast feeding, this increase in body weight cannot however be attributed to the administration of the extract.

Plasma Prolactin level for group A (170.00 ± 2.82), B (150.00 ± 14.14), C (159.00 ± 1.41) and D (121.00 ± 46.68) displayed an increase in the amount of total prolactin concentration at the first, second, and the third week of the study, (table 4.2). Albeit the values for the study groups A, B, and C were different and higher than the values of control group D, there is however no significant difference ($p > 0.05$) between the prolactin levels of the various groups. Hence, it can be suggested that the millet husk extract may have affected the prolactin biosynthesis which resulted in the increase of total prolactin concentration and consequently the breast milk. However, the possible mechanism of action of millet husk on prolactin concentration has not yet been clarified and hence the need for further studies.

Table 1. Initial and final weights (grams) of rats fed grower feed and millet husk extract

Groups	Initial Weight (g)	Week One Weight (g)	Week Two Weight (g)	Week Three Weight (g)	Prolactin (ng/ml)
A (5%)	186.67 ± 30.55	196.67 ± 30.55	193.33 ± 11.54	190.00 ± 20.00	170.00 ± 2.82
B (10%)	170.00 ± 45.83	173.33 ± 35.12	176.67 ± 25.17	170.00 ± 40.00	150.00 ± 14.14
C (15%)	196.67 ± 15.27	203.33 ± 11.54	206.67 ± 15.27	210.00 ± 10.00	159.00 ± 1.41
D (H ₂ O)	180.00 ± 10.00	190.00 ± 10.00	183.33 ± 15.28	186.67 ± 11.54	121.00 ± 46.68

CONCLUSION

Millet husk did not increase plasma Prolactin level in lactating albino rats. Therefore, it is recommended that further work should be carried out in view of this research and to unveil other potentials of the plant product.

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SENSORY AND MICROBIAL PROPERTIES OF COMPLEMENTARY FOOD PRODUCED FROM ROASTED AND MALTED MAIZE AND AFRICAN YAMBEAN FLOUR BLENDS

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Abstract

Maize and African yam bean grains were steeped in water (1:3w/v for 18 hours, germinated for 4 days and sun dried. Another batch of maize and African yam bean (AYB) grains were roasted separately over heated aluminum pan at 210°C for 20 minutes. The processed samples were milled using a hammer mill and sieved to obtain fine flour (mesh size, 200µm) then composite to produce complementary foods containing 70:30 (roasted maize:roasted African yambean flour); 70:30 (maize malt and: African yam bean malt), 70:20:10 (roasted maize: roasted African yam bean: African yam bean malt) and 70:20:10 (maize malt: African yam bean malt: roasted African yam bean) were produced. The sensory and microbial properties of the gruel from the blends were evaluated. Sensorial results showed that the blend 70: 30 (roasted maize:roasted African yam bean) was very much liked in terms of appearance, taste, consistency, after-taste and overall acceptability. Incorporation of 10% African yambean malt in the roasted sample slightly reduced the likeness of its sensorial attributes while introduction of 10% roasted AYB in the malted product improves the preference of the product by the panelists. The mould and total viable counts (CFU/g) of the complementary food were generally low and the mould values ranged from 1.0×10^1 to 4.0×10^1 cfu/g.

Keywords: Complementary food, African yambean, Malting, Roasting, Maize grain

Introduction

In developing countries like Nigeria, complementary foods are mainly based on starchy tubers like cocoyam, sweet potato and Irish potato or on cereals like maize, millet and sorghum. Children are normally given these staples in the form of gruels that are either mixed with boiled water or boiled with water (Igyoret *et al.*, 2011). Many families often depend on inadequately processed traditional complementary foods consisting mainly of unsupplemented cereal gruels made from maize, sorghum and millet (Ibe, 2008). These cereals are eaten in large quantities in developing countries and used to feed infants (Ikujenlola, 2008). Due to their high viscosity on cooling, a large amount of water is used during preparation to obtain the right consistency. The high viscosity characteristics of cereal grain are obviously responsible for young children's inability to fulfill their energy and nutrient requirements (Kikafunda *et al.*, 2006).

Complementary foods prepared with appropriate processing and blending of locally available food commodities improve the nutrient density and nutrient intake and can prevent malnutrition (Uvereet *al.*, 2010; Onwuraforet *al.*, 2020).

Maize grain is among the indigenous crops used traditionally for complementary food preparation. Many researches are ongoing in the country Nigeria especially on how to improve the Nigerian indigenous complementary food. Recent advances include preservation, complementation, fortification, and optimization (Bristoneet *al.*, 2021). Different cereal grains have been complemented with different legumes to boost the nutrient content. For instance fermented maize flours has been complemented with mungbean malt (Onwuraforet *al.*, 2020; bambara groundnut malt (Uvereet *al.*, 2010) with the aim of improving the shelf-life stability and at the same time increasing the nutrient and energy density of gruel and achieve viscosity reduction through the use of legume malt. African yam bean (*Sphenostylisstenocarpa*) is a lesser-known legume of tropical areas of the world which has attracted research attention in recent time. The high protein content of African yam bean along with relatively high levels of lysine, tryptophan and certain minerals provides a sound basis for using African yam bean to supplement maize flour. Bristoneet *al.* (2021) noted that the technology for processing and preserving indigenous foods for later use were lacking and have put the country in food shortages due to wastage. Good technology for processing and preservation of those indigenous foods would yield abundant wholesome foods for Nigerian and other parts of the world. The application of malting and roasting available in Nigeria and their effects on sensorial and microbial contamination requires some attention.

Materials and methods

Yellow maize (*Zea mays*), African yam bean (*Sphenostylisstenocarpa*) and all reagents used were procured from Ogigi Market, Nsukka, Enugu State, Nigeria. The grains of maize and African yam bean were cleaned and 2 kg of each grain was separately washed, soaked in water (1:3 w/v) for 18 hours, drained, spread in a woven basket and allowed to germinate for 4 days with water sprinkling at 5 hours interval. The grain malt were sun dried, milled, sieved (0.2 mm mesh screen) and packaged. The second portion of each grain (2 kg) was conditioned with water, roasted at temperature of 210 °C for 20 minutes in heated aluminium pan over charcoal fire. The roasted grains were milled, sieved. The malted and roasted maize and African yam bean flours were blended in different ratios as 70:30 (roasted maize: roasted African yam bean), 70:30 (maize malt: African yam bean malt), 70:20:10 (roasted maize: roasted African yam bean: African yam bean malt), 70:20:10 (maize malt: African yam bean malt: roasted African yam bean). Sensorial properties of the complementary foods were determined according to Ihekoronye and Ngoddy (1985). The sensorial properties were determined using twenty (20)

panelists and the attributes (appearance, flavour, consistency, taste, after-taste, mouth-feel, and the overall acceptability) were scored using 9-point Hedonic scale (where “9” means extremely like, “1” means extremely dislike). Mould and total viable counts were determined as described by Prscott *et al.* (2005). Data obtained were subjected to statistical analysis using one way analysis of variance (ANOVA) (Steel and Torrie, 1981). The mean separation was done by Duncan New Multiple Range Test using SPSS version 20.00 Software. Significance was accepted at $p < 0.05$.

Results and Discussion

The results of malting and roasting effect on the sensorial properties of the complementary foods are shown in Table 1. The mean scores for appearance and flavour of gruel made from roasted maize malt supplemented

Table 1: Sensory properties of the flour of complementary food from roasted maize malt –African yam bean malt

Sample Blends	Parameters						
	Appearance	Flavour	Taste	Consistency	Mouth-feel	After-taste	Overall acceptability
RM ₇₀ RAYB ₃₀	7.35 ^{ab} ±1.38	7.25 ^{ab} ±1.37	6.30 ^b ±1.37	5.45 ^{ab} ±1.98	6.30 ^b ±1.62	6.55 ^b ±1.60	7.25 ^{ab} ±1.37
RM ₇₀ RAYB ₃₀ + sugar	8.05 ^a ±0.94	7.75 ^a ±1.01	7.85 ^a ±1.34	5.75 ^a ±1.99	7.65 ^a ±0.87	7.70 ^a ±1.08	7.75 ^a ±1.01
MM ₇₀ AYBM ₃₀	7.10 ^{ab} ±1.29	4.60 ^{cd} ±2.01	4.80 ^c ±1.36	5.60 ^{ab} ±2.21	4.80 ^c ±1.36	4.50 ^{cd} ±1.98	4.60 ^{cd} ±2.01
MM ₇₀ AYBM ₃₀ + sugar	7.60 ^{ab} ±1.23	4.10 ^{cd} ±2.04	3.85 ^d ±1.69	5.30 ^{ab} ±1.92	4.40 ^{cd} ±1.93	4.25 ^{cd} ±2.19	4.10 ^{cd} ±2.04
RM ₇₀ RAYB ₂₀ A YBM ₁₀	7.15 ^{ab} ±1.34	4.15 ^{cd} ±2.21	3.70 ^d ±1.45	4.70 ^{cd} ±1.53	3.70 ^d ±1.49	3.95 ^d ±1.48	4.15 ^{cd} ±1.87
RM ₇₀ RAYB ₂₀ A YBM ₁₀ + sugar	7.50 ^{ab} ±1.27	3.95 ^d ±2.04	3.90 ^d ±1.58	4.85 ^c ±1.63	4.10 ^{cd} ±1.83	4.00 ^{cd} ±1.94	4.00 ^{cd} ±2.00
MM ₇₀ AYBM ₂₀ R AYB ₁₀	6.75 ± 1.35	4.95 ^c ±1.76	5.15 ^{bc} ±1.49	5.00 ^{ab} ±1.84	5.15 ^c ±1.49	5.20 ^c ±1.54	5.25 ^{cd} ±1.77
MM ₇₀ AYBM ₂₀ R AYB ₁₀ + sugar	6.70 ^{cd} ±1.26	5.0±1.94	5.05 ^{bc} ±2.06	5.15 ^{ab} ±2.1	5.15 ^c ±1.97	4.75 ^{cd} ±2.11	5.55 ^{cd} ±2.45

Values are means ± standard deviation of triplicate determination. Values bearing different superscripts in the same column are significantly different ($p < 0.05$).

Key: RM₇₀RAYB₃₀ = 70:30 (Roasted maize: Roasted African yam bean); RM₇₀RAYB₃₀+Sugar = 70:30 (Roasted maize: Roasted African yam bean) with sugar. MM₇₀AYBM₃₀ = 70:30 (Maize malt: African yam bean malt); MM₇₀AYBM₃₀+Sugar = 70:30 (Maize malt: African yam bean malt) with sugar. RM₇₀RAYB₂₀AYBM₁₀ = 70:20:10 (Roasted maize: Roasted African yam bean: African yam bean malt) RM₇₀RAYB₂₀AYBM₁₀+Sugar =

70:29:10 (Maize malt: African yam bean malt: Roasted African yam bean) with sugar; $MM_{70}AYBM_{20}RAYB_{10} = 70:20:10$ (Maize malt: African yam bean malt:Roasted African yam bean); $MM_{70}AYBM_{20}RAYB_{10}+Sugar = 70:20:10$ (Maize malt: African yam bean malt :Roasted African yam bean+Sugar)

withroasted AYB malt in the ratio of 70:30 were 7.35 and 7.25, respectively indicating that the products were moderately liked by the panelists. However, addition of sugar to the gruel improves the degree of likeness of the products causing the panelist to like the appearance and flavourvery much (mean score of 8.05 and 7.75, respectively).The flavour scores of the complementary food differed significantly ($p<0.05$) among formulated roasted sample, malted sample, roasted samples supplemented with malted 10 % AYB malt. The values ranged from 3.95 to 7.75. Taste and after-taste were slightly liked by the panelists considering their scores which fell between 6.30 and 6.55. These parameters were rated high by the panelists when sugar was added.This means that addition of sugar positively affected preference for the taste, after-taste and mouth-feel of thecomplementary food indicating that the product need to be consumed with sugar or other sweeteners for maximum satisfaction of the consumers.Addition of AYB malt reduced the likeness for the taste of the products which improved slightly with addition of sugar. The taste of the roasted flour blends differed from the other blends indicating that roasting accentuated theflavour and taste of the products.In terms of consistency, there were no significant($p>0.05$)differences amongformulated roasted samples with or without sugar (samples $RM_{70}RAYB_{30}$ (5.45), $RM_{70}RAYB_{30}+ sugar$ (5.75) and $MM_{70}AYBM_{30}$ (5.60)). However, marginal differences occurred in preferences when 10% roasted AYB was introduced into the malted formulation

The value for mouth-feel ranged from 3.70 to 7.65. Sample formulated from roasted samples scored highest (6.30) which was very much liked by the panelist with addition of sugar (7.65). The high score for the mouth-feel of the complementary food is an indicator of the digestibility of the food when taken showing that it has low fibre and adequate oil absorption capacity.The overall acceptability followed the same trend as mouth-feel. Roasted samples were preferred by the panelists and very much liked with addition of sugar. Use of malted samples and introduction of 10% roasted AYB malt in the products had no significant($p<0.05$) effect on the after-taste preference and overall acceptability of the complementary food. There was marginal difference between sample $RM_{70}RAYB_{30}$ (7.25) and sample $RM_{70}RAYB_{30} + sugar$ (7.75) indicating that the complementary food formulated from roasted samples was very much liked with or without sugar. Introduction of AYB malt in roasted complementary food sample led to reduction of overall acceptability score probably due to raw taste introduced by the malt. This shows that amount of heat applied in preparation of the sample containing malt may not have cooked the sample properly. The preference by the panelist of

sample RM₇₀RAYB₃₀ + sugar formulated from 70:30 (Roasted maize: Roasted African yam bean) could be due to the desirable flavour impacted on the sample during roasting.

Microbial Count of Maize- African yam bean flour blends

The results of the mould and total viable counts (CFU/g) of maize- African yam bean complementary foods are shown in Table 2. The mould counts (CFU/g) for the complementary foods were generally low; this

Table 2: Mould and Total Viable Counts (CFU/g) of maize- African yam bean complementary food

Blends	Mould Count	Total Viable Count
RM ₇₀ RAYB ₃₀	2.0x10 ¹	3.1x10 ⁵
MM ₇₀ AYBM ₃₀	2.3x10 ²	2.29x10 ⁵
RM ₇₀ RAYB ₂₀ AYBM ₁₀	1.0x10 ¹	2.58x10 ⁵
MM ₇₀ AYBM ₂₀ RAYB ₁₀	4.0x10 ¹	2.41x10 ⁵

Key: Key: RM₇₀RAYB₃₀ = 70:30 (Roasted maize: Roasted African yam bean); MM₇₀AYBM₃₀ = 70:30 (Maize malt : African yam bean malt) ; RM₇₀RAYB₂₀AYBM₁₀ = 70:20:10 (Roasted maize: Roasted African yam bean: African yam bean malt) ; MM₇₀AYBM₂₀RAYB₁₀ = 70:20:10 (Maize malt: African yam bean malt :Roasted African yam bean)

would probably be due to the method of handling during processing. RM₇₀RAYB₃₀ and RM₇₀RAYB₂₀AYBM₁₀ had the least mould count of 2.0x10¹ CFU/g and 1.0x10¹ CFU/g, respectively. This could probably be due to application of heat during roasting. The total viable count of the samples RM₇₀RAYB₃₀ to MM₇₀AYBM₂₀RAYB₁₀ were 3.1x10⁴ CFU/g, 2.29x10⁵ CFU/g, 2.558x10⁵ CFU/g and 2.41x10⁵ CFU/g, respectively. The low value of both the mould count and total viable count of the complementary foods is an indicator that the food is a dried product, could not encourage the proliferation of microorganism and could be safe for consumption.

Conclusion

The study has shown that simple technologies of roasting and malting can be used to produce acceptable and safe complementary foods. Roasted sample taken with sugar is preferred by the panelist. The use of malting and roasting together as a simple technology of processing in enhancing flavour and nutrient content should be encouraged among users.

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NUTRITIONAL ASSESSMENT OF COMPLEMENTARY FOOD FROM BLENDS OF SPROUTED SORGHUM AND ORANGE-FLESHED SWEET POTATO

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ABSTRACT

The objective of this research work was to produce complementary food from the blends of sprouted sorghum (SS) and orange-fleshed sweet potatoes (OFSP) at ratio of 100:0 SS, 90:10 SS/OFSPa, 80:20 SS/OFSPb, 70:30 SS/OFSPc, and 60:40 SS/OFSPd, respectively. The different ratios were subjected to chemical analyses which include functional properties, proximate composition, in-vitro starch, and protein digestibility, sensory evaluation. The results showed that the bulk density ranged 0.60 – 0.98 g/ml³, water absorption capacity ranged 86.65 – 92.64 %, viscosity ranged 344.53 – 471.12 ml³, gelation temperature ranged 69.50 – 74.05°C, gelation capacity ranged 17.53 – 23.53%. The proximate composition moisture ranged 6.30 – 6.80 %, ash ranged from 4.63 – 8.97 %, carbohydrate ranged 63.73 – 71.63 %, crude fibre ranged 1.22 – 4.21 %, in-vitro protein digestibility at 1 hr., 6hrs, and starch digestibility at 2 hrs. are 82.45, 84.30 and 55.59 for SS; 84.55, 86.00 and 58.36 for SS/OFSPa; 85.42, 88.15 and 60.73 for SS/OFSPb; 86.96, 90.07 and 62.04 for SS/OFSPc and 88.15, 91.45 and 64.16 for SS/OFSPd, respectively. There was statistical significant difference ($p < 0.05$) for overall acceptability, colour, flavor/aroma, consistency and mouth feel as the F-calculated for these parameters, 17.26, 7.00, 6.94, 4.59 and 6.24, respectively are higher than the F-tabulated 3.74 at 5% level of acceptance, while the taste result showed that there was no significant difference in the samples as the F-calculated 0.18 was lesser than the F-tabulated, 3.74 at 5% level of acceptance.

KEYWORDS: Sprouted Sorghum, Orange-Sweet Potato, in-vitro protein digestibility, Bulk density, Gelation temperature, viscosity

Introduction

Exclusive breastfeeding for full-term infants has been recommended for the first 6 months of life by healthy well-nourished mothers (Ikujenlola, 2016). However, immediately after this period, breast milk cannot adequately sustain the nutrients and energy requirements of the infant; hence the need for the introduction of complementary food that can help augment on this additional needs to meet the nutritional requirements of the growing child (Ikujenlola, 2016). Complementary foods are the foods given to infants alongside with breast milk with the purpose of supplying the needed additional nutrients and energy that the breast milk cannot adequately provide because of the additional physical and physiological demands (Abiose *et al.*, 2015). Complementary feeding is needed to provide energy and essential nutrients required for continued growth and development of infants from 6 months. The recommended feeding practices during this time ensure that the baby receives all the necessary nutrients, including those that are sometimes missing for many babies (iron, zinc, and vitamin A).

Sorghum is a cereal crop which belong to *poaceae* race, a tropical plant that ranks 5th most vital crop in different locations of the world including Latin America, Asia, and Africa after rice, wheat, maize, barley, and 3rd in importance in the developing countries (Salazar-López, *et al.*, 2018), such as Nigeria, Sudan, India (Afify, *et al.*, 2012). Sorghum consumption in the low incomes countries is 78% of the total production, 7% and 14% for industrial uses and livestock feeds, respectively (Claver *et al.*, 2011). Sorghum is an outstanding crop rich in vital nutrients that major requirements for the growing infants. Sorghum is rich in minerals such as iron, zinc, calcium, magnesium, vitamins (B-vitamins) and other non-nutrients that are important components of food (Afify, *et al.*, 2012; Claver *et al.*, 2011).

Orange Fleshed Sweet potato (OFSP) is a biofortified breed of sweet potato that was developed to address the menace of micronutrient deficiency especially that of vitamin A in children. Apart from the other nutrients contained in sweet potato such carbohydrates, fibre minerals and vitamins, it is an excellent vehicle for biofortification for some nutrients like vitamin A. Consequently, the objective of this study is to produce and evaluate the nutritional quality of complementary food from flour blends of sprouted sorghum and orange flesh sweet potato.

MATERIALS AND METHODS

MATERIALS

The raw materials, Orange Fleshed Sweet Potatoes (OFSP) and Sorghum (*Sorghum bicolor* L. *moench*) were purchased from Raw Material Research Development Council outlet in Kaduna, Kaduna state and Kaura Namoda market, Kaura Namoda local government, Zamfara state, respectively.

METHODS

The OFSP was processed into flour and the Sorghum was sprouted prior to drying and milling. Respective blends were formulated and subjected to quality evaluation (proximate analysis and functional properties).

RESULTS AND DISCUSSION

The results for functional properties for the flour blends are shown on table 1.

Table 1. Functional Properties of the Flour Blends

Sample	BD (g/ml ³)	VC (ml ³)	GC %	WA%	GT°C	EC %
SS	0.60±0.01 ^a	344.53±0.02 ^a	7.25±0.00 ^a	92.64±0.01 ^c	73.15±0.00 ^b	17.53±0.02 ^a
SS/OFSPa	0.62±0.01 ^a	387.65±0.01 ^b	7.87±0.01 ^b	90.12±0.01 ^d	74.05±2.12 ^b	19.15±0.01 ^b
SS/OFSPb	0.74±0.01 ^b	411.15±0.00 ^c	8.15±0.00 ^c	89.53±0.02 ^c	72±0.00 ^{ab}	21.14±0.01 ^c
SS/OFSPc	0.87±0.01 ^c	435.27±0.01 ^d	8.68±0.01 ^d	87.95±0.01 ^b	70.09±0.01 ^a	22.86±0.02 ^d
SS/OFSPd	0.98±0.00 ^d	471.12±0.01 ^e	8.96±0.01 ^e	85.96±0.01 ^a	69.5±0.00 ^a	23.53±0.02 ^e

Values are the means of duplicate determinations ± Standard Deviation.

Values with same letters at a column show that there is no significant difference.

KEY:

SS: Sprouted Sorghum = 100: 0

SS/OFSPa-Sprouted Sorghum/Orange fleshed Sweet Potato = 90: 10

SS/OFSPb - Sprouted Sorghum/Orange Fleshed sweet Potato = 80: 20

SS/OFSPc - Sprouted Sorghum/Orange Fleshed Sweet Potato = 70: 30

SS/OFSPd - Sprouted Sorghum/Orange Flesh Sweet Potato = 60: 40

BD: Bulk density

VC: Viscosity

GC: Gelatinization capacity

WA: Water absorption capacity

GT: Gelatinization temperature

The results for the proximate composition for the flour blends are shown on table 2.

Table 2. Proximate Composition of Flour Blends

SAMPLES	C. PROTEIN %	C. FIBRE %	ASH %	MOIST. %	CHO %
SS	10.25±0.01 ^a	1.22±0.00 ^a	4.63±0.00 ^a	6.30±0.00 ^a	71.73±0.02 ^c
SS/OFSPa	12.85±0.00 ^b	1.67±0.00 ^b	7.50±0.00 ^b	6.55±0.00 ^a	66.39±0.02 ^b
SS/OFSPb	13.76±0.01 ^c	1.70±0.00 ^c	8.62±0.00 ^c	6.80±0.00 ^a	66.34±0.01 ^b
SS/OFSPc	14.15±0.00 ^d	2.80±0.00 ^d	8.83±0.01 ^d	6.75±0.00 ^a	65.66±0.68 ^b
SS/OFSPd	16.29±0.01 ^e	4.21±0.01 ^e	8.95±0.00 ^e	6.50±0.00 ^a	63.73±0.02 ^a

Values are the means of duplicate determinations ± Standard Deviation.

Values with same letters at a row show that there's no significant difference.

KEY:

SS - Sprouted Sorghum= 100: 0

SS/OFSPa - Sprouted Sorghum/Orange Fleshed Sweet Potato = 90: 10

SS/OFSPb - Sprouted Sorghum/Orange Fleshed Sweet Potato = 80: 20

SS/OFSPc - Sprouted Sorghum/Orange Fleshed Sweet Potato = 70: 30

SS/OFSPd - Sprouted Sorghum/Orange Fleshed Sweet Potato = 60: 40

DISCUSSION

The findings of this research work showed that the functional properties of the various flour blends (table 1) there were significant difference except in bulk density ratios (100:0 and 90:10) and gelation temperature ratios (100:0, 90:10, 80:20, 70:30 and 60:40).

The values for viscosity, gelation capacity, emulsion capacity, increased with increased in OFSP flour inclusion, however, the water absorption capacity and gelation temperature decreased.

The functional properties of flour are central to its usability and functionality during product development (processing) and storage. Bulk density is a measure of heaviness of flour, the lower the value the better the product (complementary food). This is because the density allows for nutrient dense and energy which are very important for infants and children growth and development (Cimatti & Campana, 2016). The viscosity and the gelation capacity are good properties for complementary food ((Mitra, 2016;Awuni, *et al.*, 2017).

The results of proximate composition of flour blends (table 2), showed significant differences in crude protein, crude fat, crude fiber, ash, and carbohydrate content of the samples at 5% level of significance, while the moisture content showed no statistically significant difference. The values for crude protein, crude fat, crude fiber, and ash increased significantly with increased OFSP flour inclusion ((Mitra, 2016; Awuni, *et al.*, 2017)

Crude protein ranged from 10.25 to 16.29 % with 100% sprouted sorghum having the least value. Crude fat ranged from 5.87 to 7.50% 100% sprouted sorghum having the least value. The increment in the content of blend proportions due to the addition of OFSP which agree with the findings of Mitra (2016), who reported that OFSP had a higher content of fat.

Crude fiber content was increased when more OFSP was added to the sprouted sorghum. This was due to the increased in the fiber contents of OFSP which was in the range of 1.22 to 4.21 %, for samples SS and OFSPd, respectively. This is an added advantage to the flour blends and current research as OFSP is high in fiber, thus prevents dehydration, as well as improves digestibility ((Mitra, 2016; Awuni, et al., 2017).

Ash content of the samples ranged from 4.63 to 8.95% with that from 100% sprouted sorghum having the least and that 40% OFSP the highest. This increment could be because of high content of minerals found in the OFSP and sorghum (Mitra, 2016; Low, 2020).

Moisture content of the samples which were significantly different and ranged from 6.30 to 6.50%. Blends were similar in moisture contents. Lower levels of moisture could be an added advantage in the storage stability of the flour blends.

Carbohydrate content decreased with increase in OFSP addition to the sprouted sorghum. The values ranged from 71.73 to 63.73% with that from 40% OFSP (sample E) having the least and that from 100% sprouted sorghum the least (Low, 2020)

Conclusion

The resultsshowed that complementary food can be produced from flour blends of OFSP and sprouted sorghum, however, sample OFSPd (60:40) was the highest in protein, fibre, and ash, most acceptable in terms of all the sensory attributes for complementary food, therefore, the formulation would be a good option to produce complementary food for children between the age of 6 months and 24 months.

Recommendations

We recommend for both in-vitro as well the in-vivo starch and protein digestibility of the complementary food.

Microbial analysis was also recommended to assess the load (microbial loads).

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CHAPTER 8

FOOD ENGINEERING, WATER AND MISCELLANEOUS

EFFECT OF CONDITIONING ON THE SPECIFIC HEAT CAPACITY OF PIGEON PEA (*CAJANUS CAJAN*)

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ABSTRACT

White and red Pigeon pea (*Cajanuscajan*) seeds were conditioned with tap water to moisture contents of 15, 20, 25 and 30% (d.b) and temperature of 30°C, 40°C and 50°C respectively and the specific heat capacity determined. The results obtained show that the specific heat capacity of the seed decreased linearly at a range of 4.140 to 3.365 Jkg⁻¹k⁻¹ for white variety and 4.185 to 3.185 Jkg⁻¹k⁻¹ for red as moisture content increased from 15 to 30% (d.b) respectively. These values indicate the ability of pigeon pea seed not to retain heat when processed. The regression models that could be used to adequately express the relationship between the specific heat capacities of the pigeon pea seed and moisture content were established with high value of coefficient of determination. This indicates a high effect of moisture content on the specific heat capacity of red and white pigeon pea.

Keywords: Pigeon pea, Specific heat Capacity, Moisture content, Temperature.

1.1 INTRODUCTION

One of the most widely cultivated food legumes in the tropical and subtropical parts of Africa and Southeast Asia is the pigeon pea (*Cajanuscajan*), often known as red gram (Lai, *et al.*, 2012; Olawuniet *al.*, 2012). According to FAO (1982), the pigeon pea's approximate nutritional composition is 20 to 22% protein, 1.2% fat, 65% carbohydrates, and 3.8% ash. It is a valuable source of crude fiber, water-soluble vitamins (thiamine, riboflavin, and niacin), minerals (iron, sulfur, calcium, potassium, and manganese), and some essential amino acids, including leucine, lysine, phenylalanine, isoleucine, and valine (Onwuka, 2006; Sharma *et al.*, 2011).

The green pods and seeds are the most utilized form in Africa though dry seeds are increasingly gaining popularity. In Nigeria, for example, the dry seeds are cooked whole until tender then mixed with cooked yam maize, dried cocoyam grits or freshly cooked cocoyam in addition to vegetables palm oil salt pepper and other spices (Enwere, 1998). Thermal properties of food and agricultural products are important parameters that often indicate how the food material react to heat fluctuation and significantly affect physical treatment received during processing. They are also the most common indicator of other properties and qualities. The understanding of these thermal properties is necessary for efficient process design and production processes (Aviara *et al.*, 2008).

According to Bozikova (2007), the biochemical makeup of agricultural materials caused the thermal conductivity, thermal diffusivity, and specific heat to drop as the moisture content rise. The thermal parameters of the *Cajanuscajanis* therefore critical in order to mechanize

the processing of such seeds effectively and get the desired results. A review of the literature reveals that there aren't many studies on the *Cajanuscajan* seed's temperature fluctuation characteristics. The aim of this paper therefore, is to evaluate the effects of conditioning on the specific heat capacities of red and white pigeon pea (*Cajanuscajan*).

2.0 Materials and Methods

2.1 Material

The pigeon pea (*Cajanuscajan*) was purchased from Abakpa main market (meat market) Abakaliki L.G.A of Ebonyi State, Nigeria.

2.2 Sample Preparation

The seed was cleaned manually to remove all foreign matters such as dust, dirt, spoilt seed chaff and some extraneous materials.

2.3 Specific Heat Measurement

The specific heat was determined using the method of modified mixtures following the procedure proposed by Jindal and Murakami (1984). The specific heat calorimeter consisted of a vacuum flask with a styrofoam insulation cover to prevent heat loss. A rubber O-ring was attached to the edge of the flask to provide additional sealant for heat loss.

Thermocouples of type K and size of 0.65mm in diameter was inserted through the center of the lid into calorimeter (Model: 5E-AC/PL, China). The heat capacity of vacuum flask calorimeter with a polythene bag was calibrated using distilled water and found to be 0.124kJ/°C, which was within the range of reported values by Sabapathy and Tabil (2004) of 0.457kJ/°C and Jindal and Murakami (1984) of 0.055kJ/°C.

A 500ml sample of water with a temperature 20°C lower than the sample was used for each measurement (that is, 10°C for samples 30°C, 20°C for 40°C and 30°C for 50°C samples respectively). The sample was mechanically stirred and maintained at constant temperature of 30, 40, 50°C in the water bath. The sample was quickly weighed and put inside a polyethylene bag of size 127 x 203.2 x 0.025mm to prevent mixing. The temperature changes of water and sample in the vacuum flask calorimeter was recorded every 1min with a resolution of 0.1°C by a datalogger model DW-40BT T/C-V (ECD, Data worker 10/40, Milwaukie, OR, USA). The vacuum flask calorimeter was continuously shaken to prevent sedimentation in order to reach peak temperature in about 10min of treatment and then shaken every 5min to reach equilibrium temperature in 120min. A heat calculated following the heat balance equation (2) as follows:

$$C_w W_s (\Delta T_s) = C_w W_w (\Delta T_w) + H C (\Delta T_c) \text{ ----- Equation (ii)}$$

Where C is the specific heat (KJ/Kg°C). W is the weight (kg), T is the difference between the initial temperature and the equilibrium temperature (°C), H is the heat capacity of the calorimeter (KJ/°C), and the S, W, and C subscripts refers to the starch solution, water and calorimeter, respectively.

3.1 Results and Discussion

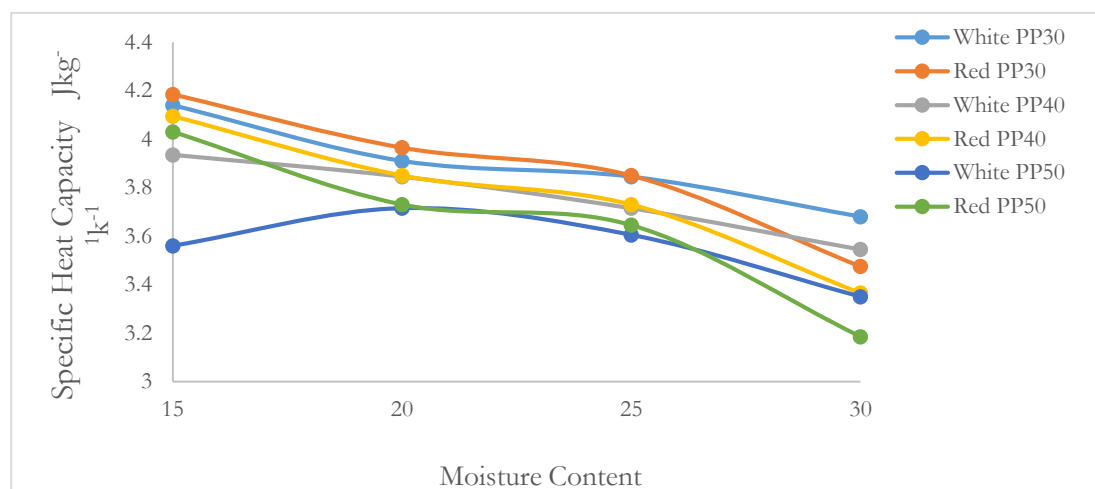


Figure 1: Effect of specific heat capacity on moisture content of white and red pigeon pea at different temperature treatments.

The red pigeon pea had higher specific heat capacity when compared to white pigeon pea as can be seen from Figure 1. As temperature treatment was applied, the red pigeon pea responded better to heat treatment than white pigeon pea leading to the interceptions between the red and the white pigeon pea at different point on the graph as moisture content increased. The red pigeon pea responded fast to change in temperature and moisture content leading to interception at moisture content of 20 %d.b and at temperature conditioning of 40-50 °C while interception occurred for 30 °C conditioned at moisture content of 25 %d.b. In a similar observation, both the white and the red pigeon peas had higher specific heat capacities when the moisture content was 15, except for red pigeon pea at temperature 50 °C, which was higher the white pigeon pea at temperature 40 °C. It was noticed that higher temperature and moisture content led to reduced specific heat capacity. The specific heat capacity of pulses depends greatly on moisture content and temperature. According Deshpande and Bal (1999), the specific heat capacity for soyabean at increases with increase in moisture and at a constant temperature of 315K (41.85°C).

3.2 Conclusion

According to the findings of this study on the effects of conditioning on the specific heat capacity of red and white pigeon peas, the specific heat capacity decreased linearly with increasing moisture content and conditioning temperature. The study concludes with data on the specific heat capacity of pigeon pea seed varieties conditioned at various temperatures, which may be useful in designing much of the equipment used in pigeon pea processing.

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THERMAL, GRAVIMETRIC AND ENGINEERING PROPERTIES OF PIGEON PEA (*CAJANUS CAJAN L.*) GROWN IN NIGERIA

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Abstract

Due to inadequate information on the thermal, physical and engineering properties of pigeon pea grown in Nigeria some of these properties were studied in order to contribute to the database for properties related to grading, handling, packaging, transportation, cleaning, processing, storage and other futuristic processing units. The proximate analyses, thermal, gravimetric, and engineering properties of the dried pigeon pea seeds were conducted using standard methods. This study showed that the thermal conductivity, specific heat capacity, latent heat and thermal diffusivity were $0.33 \pm 0.01 \text{ Wm}^{-1}\text{K}^{-1}$, $1.59 \pm 0.10 \text{ KJ Kg}^{-1}\text{K}^{-1}$, $19.72 \pm 0.11 \text{ KJ Kg}^{-1}$ and $0.16 \pm 0.12 \times 10^{-7} \text{ m}^2 \text{s}^{-1}$. The bulk density, true density and porosity were $0.77 \pm 0.04 \text{ kgm}^{-3}$, $1.29 \pm 0.10 \text{ kgm}^{-3}$ and $39.89 \pm 4.96 \%$ respectively. This study also revealed that the angle of repose and coefficient of static friction for formica, glass, stainless steel and plywood were $25.20 \pm 0.70^\circ$, 0.31 ± 0.04 , 0.30 ± 0.02 , 0.34 ± 0.03 and 0.34 ± 0.04 respectively. Glass had the lowest coefficient of static friction and so will be most suitable among the materials tested for the production of pigeon pea seeds conveying surfaces.

Keywords: Physical, thermal, engineering, properties, pigeon pea, handling, processing.

Introduction

Promotion and enrichment of underutilized cereal based foods with legumes and oilseeds have received enormous attention. Pigeon pea is a perennial and marginally known legume shrub, having the potential of reducing protein and micronutrients deficiency in developing nations. Several studies have been carried out on pigeon pea seeds and its use in novel foods production and evaluation: Nutritional composition of gluten-free flour from blend of fonio (*Digitaria iburua*) and pigeon pea (*Cajanus cajan*) and its suitability for breakfast food; Development and Quality Characteristics of Cookies from Sprouted Sorghum, Pigeon Pea and Orange Fleshed Sweet Potato Flour Blends [2]; Effect of moisture and temperature on thermal conductivity of pigeon pea seeds [5]. Data on thermal, gravimetric and engineering properties of various produce have been widely reported in the literature; however, data on pigeon pea seeds were scanty. The objective of this study was to determine the thermal, gravimetric and engineering properties of matured raw pigeon pea seed relevant to its dehulling, packing, conveying and processing.

Materials and Methods

Sample collection and preparations

Matured and dried two kilograms pigeon pea seeds were purchased in Uchi Market, Auchi, Nigeria. These were sorted to remove immature and damaged seeds and cleaned by winnowing to remove the straw particles.

Proximate Composition

Flour was prepared from the seed as described by [8]. The proximate analyses of the dried pigeon pea seeds and flour were conducted using standard methods.

Determination of thermal properties

Thermal conductivity

The thermal conductivity (K) of food materials was estimated using equation 1

$$K = 0.25m_c + 0.155m_p + 0.16m_f + 0.135m_a + 0.58m_m \dots\dots(1)$$

Where, m_c = mass of carbohydrate, m_p = mass of protein, m_f = mass of fat, m_a = mass of ash and m_m = mass of moisture present in the food material.

Specific heat capacity

The specific heat capacity of the seeds were estimated using equations 2 and 3

$$C_p = m_w c_w + m_s c_s \text{ (KJ Kg}^{-1}\text{K}^{-1}) \dots\dots\dots(2)$$

$$C_p = 1.424m_c + 1.549m_p + 1.675m_f + 0.837m_a + 4.187m_m \dots\dots\dots(3)$$

Where, c_p = specific heat capacity, m_w = mass fraction of water, c_w = specific heat capacity of water (4.18 KJ Kg⁻¹K⁻¹), m_s = mass fraction of solids, and c_s = specific heat capacity of solids (1.46 KJ Kg⁻¹K⁻¹).

Latent heat of fusion

The method of Lamb was used to estimate the latent heat of fusion as in equation 4

$$L = 335 m_w \text{ (KJ Kg}^{-1}) \dots\dots\dots(4)$$

Where, m_w = mass fraction of water.

Thermal diffusivity

The thermal diffusivity was estimated as described by Lewis [7] as

$$\alpha = K / \rho C_p \dots\dots\dots(5)$$

where α = thermal diffusivity, K = thermal conductivity, ρ = density, c_p = specific heat capacity.

Gravimetric properties

True density

The true density of the seed was determined by the toluene displacement technique using equation 6.

$$\rho_t = m/v \dots\dots\dots(6)$$

Where m is the mass of the seed in kg and v is the volume of the seed in m^3

Bulk density

The average bulk density of the seeds was determined using equation 7 as described in [3]

$$\text{Bulk density (Pb)} = \text{Weight of material packed} / \text{bulk volume} \dots\dots\dots(7)$$

Porosity

Porosity (E) was computed as described in [9]

$$E = 1 - \frac{\rho_b}{\rho_t} \times 100 \dots\dots\dots(8)$$

Where ρ_b = bulk density, ρ_t = true density

Engineering Properties

Angle of repose

The emptying angle was determined using the method of [4] as

$$\Theta = \tan^{-1} (2H / D) \dots\dots\dots(9)$$

Where Θ = Angle of repose, H = Height of the pile, D = Diameter of the pile

Coefficient of static friction

The static coefficient of friction (μ) was determined for formica, plywood, stainless steel, and glass according to the method in [9] as

$$\mu = \tan \beta \dots\dots\dots(10)$$

where μ = coefficient of static friction for the structural material, β = angle of inclination

$$\beta = \tan^{-1}$$

i.e. *Vertical height of inclined plane/ base length of the platform*

Statistical analysis

The data obtained were statistically analyzed using Analysis of Variance (ANOVA) with the use of Statistical Package for Social Sciences (SPSS) version 23. The means were compared and separated using Duncan's Multiple Range Test (DMRT) and LSD at $p \leq 0.05$.

Results and Discussion

Thermal properties

The results of the thermal properties of pigeon pea seeds are presented in Table 1. The thermal conductivity of the seed was significantly higher than that of flour. The difference could be due to the removal of the germ containing most of the fat and seed coat during processing. The specific heat capacity of pigeon pea seeds obtained in this experiment was found to be lower than $1.78 \pm 0.01 \text{ KJ Kg}^{-1} \text{ K}^{-1}$ reported in [1].

Gravimetric properties

The results of the gravimetric properties obtained in this work are presented in Table 1. The value of true density obtained in this study was found to be similar to the value 1.29 reported in [6] at 7.3% moisture.

Engineering properties

The mean angle of repose and coefficient of static friction are presented in Table 1. This information are required for designing of conveyors and equipment that will be needed for moving the pigeon pea within the processing plant.

Table 1. Thermal, gravimetric and engineering properties of dried pigeon pea seeds and flour

Thermal properties parameter	Dried seeds	Flour
Thermal conductivity Wm ⁻¹ K ⁻¹	0.33±0.01 ^a	0.25±0.01 ^b
Specific heat capacity KJ Kg ⁻¹ K ⁻¹	1.59±0.10 ^b	1.70±0.01 ^a
Latent heat of fussion KJ Kg ⁻¹	19.72±0.11 ^b	25.69±0.14 ^a
Thermal diffusivity ×10 ⁻⁷ m ² s ⁻¹	0.16±0.12 ^a	0.11±0.01 ^a
Gravimetric properties parameter	Value	
True density (kgm ⁻³)	1.29±0.10	
Bulk density (kgm ⁻³)	0.77±0.04	
Porosity %	39.89±4.96	
Engineering properties parameter	Value	
Angle of repose (°)	25.20±0.70	
<i>Coefficient of static friction</i>		
Formica	0.31±0.04	
Glass	0.30±0.02	
Stainless steel	0.34±0.03	
Plywood	0.34±0.04	

Values with the same superscript along rows do not differ significantly at $P \leq 0.05 \pm \text{SD}$

Values are mean of ten determinations ($n = 10$)

Table 2. Proximate composition of dried pigeon pea seeds g/ 100g.

Parameter	Dried seed	Flour
Protein	20.56±0.52	20.64±0.54
Fat	3.68±0.29	3.86±0.31
Fibre	9.00±0.10	11.33±0.58
Ash	2.33±0.58	2.33±0.58
Moisture	6.67±0.58	7.67±0.58
Carbohydrate	57.76±0.21	57.17±0.96

Values are mean of ten determinations (n = 10)

Conclusion

The following conclusions can be made from this study on pigeon pea grown in Nigeria and at 6.67% moisture content. Glass had the least coefficient static of friction. And in designing and fabrication of hoppers and emptying bins, the angle of inclination which determine their slopes should be above 25° if fast flow of the pigeon pea is required.

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PROXIMATE AND MINERAL ANALYSIS OF *TASLYCORDYCEPS*.

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ABSTRACT

TaslyCordyceps is a Chinese herbal medicine used for treatment of many diseases including diabetes, cardiovascular problems and respiratory diseases. It is one of the growing number of Fungus traditional Chinese medicine being considered as cures for modern human diseases. The fungus represents a genus of perithecial ascomycetes (Phylum Ascomycota) which contains over 400 species and the anamorphs of most are unknown. The complex (including the larva body) has been used as a health food and traditional medicine. Thus, this aimed to determine the proximate and mineral composition of *TaslyCordyceps*. Proximate (moisture, crude protein, crude fat, ash, crude fiber and carbohydrate) and minerals (Iron (Fe), Zinc (Zn), Calcium (Ca), Chromium (Cr), Manganese (Mn) and Magnesium (Mg)) analysis of *TaslyCordyceps* were performed. The results revealed that *TaslyCordyceps* contained ash (1.02%), crude protein (8.15%), crude fat (2.0%), carbohydrate (18.26%), moisture (3.53%) and nitrogen free extract (67.04%). While results of mineral analysis showed that it contained Fe (2.87mg/g), Zn (1.31mg/g), Ca (13.33mg/g), Cr (1.73mg/g), Mn (3.33mg/g), Mg (9.33mg/g), Na (54.43mg/g), K (462.20mg/g) and P (0.54 mg/g). *Cordyceps sinensis* has been described as a fungal therapeutic biofactory due to the presence of primary metabolites like carbohydrate, protein, fat and minerals like Fe, Zn, Cr, etc. (Arora *et al.*, 2013). The results of proximate analysis of *Cordyceps* as compared with the Food and Drug Agency, clearly manifested the presence of high protein (8.15%), carbohydrate (18.26%) and low-fat content (2.0%). Thus, *TaslyCordyceps* contains many important macro nutrients (carbohydrate, protein, fats) and minerals such as Zn, and Ca, which helps to fight against several diseases (e.g. diabetes, cardiovascular diseases, etc).

Keywords: *TaslyCordyceps*, Proximate Analysis, Elemental Analysis

Introduction:

Cordyceps are nutraceuticals considered to relieve the stress for humans by stimulating basic and secondary responses of the immune system (Lakhanpal and Rana, 2005). It is a rare and exotic medicinal mushroom, known in China for centuries, and is now used by pharmaceutical industries and also as a dietary supplement. A growing number of researchers now considered it to be a super food that can be included in almost every diet.

Tasly Cordyceps is a Chinese herbal medicine in form of capsule used for treatment of many diseases including diabetes, cardiovascular problems and respiratory diseases (Zhu, Halpern and Jones, 2008). The present study was undertaken to determine the proximate and mineral composition of *TaslyCordyceps*.

Materials and Method

Sample collection

Cordyceps capsule was bought from Tasley International Pharmaceutical Company Limited, located at No.492 Kofar Famfo, B.U.K Road, Kano State.

Sample preparation

Capsule of Tasley Cordyceps was removed and the content was used as sample for proximate and elemental analysis of the study.

Proximate analysis

The proximate analysis (moisture, crude protein, crude fat, ash, crude fiber and carbohydrate) of the sample was performed according to the methods of **AOAC, 2003**.

Elemental analysis

Elemental contents of the sample were determined by atomic absorption spectrometry, flame photometry and spectrophotometer according to the methods of AOAC (2003).

Statistical analysis

The results of the proximate and elemental analysis were expressed as mean $\pm$ standard deviation.

Results and Discussion:

Result of the proximate analysis showed that, Tasley *cordyceps* contained nitrogen free extract (67.04%), carbohydrate (18.26%), crude protein (8.15%), moisture (3.53%), crude fat (2.00%) and ash (1.02%). It was observed that nitrogen free extract has the highest percentage composition while it has low percentage of ash content. Proteins functions as an enzymes, hormones, growth factors and perform hereditary transmission by nucleoproteins of the cell nucleus and their deficiency diseases include: abdominal enlargement, vomiting, diarrhea, nephrosis, lassitude, oedema, kwashiorkor (protein malnutrition), marasmic kwashiorkor. The low moisture content in *cordyceps* indicates a high shelf life.

Result of minerals composition in table 2 showed that, Tasley *cordyceps* contained an appreciable amounts of minerals in which potassium is the highest and Phosphorus is the lowest.

The presence of these essential nutrients and minerals found in *Cordyceps* implies that it can be utilized for its medicinal values in healthcare delivery systems.

Table 1: Proximate composition of *Tasley Cordyceps*

Parameters	Values (%)
Moisture	3.53±0.40
Ash	1.02±0.02
Crude Protein	8.15±0.04
Crude Fat	2.00±0.01
Carbohydrates	18.26±0.06
Nitrogen Free Extract	67.04±0.00

Values are expressed as mean ± SD (n=3).

Table 2: Mineral Composition of *Cordyceps*

Minerals	Amount in ppm
Iron	2.87±1.50
Zinc	1.31±0.85
Calcium	13.33±6.70
Chromium	1.73±1.13
Manganese	3.33±1.53
Magnesium	9.33±6.11
Potassium	462.20±20.36
Sodium	54.43±18.97
Phosphorus	0.54±0.00

Values are expressed as mean ±SD (n=3).

Conclusion and Recommendation:

From the results obtained, it can be concluded that *Tasley cordyceps* contains many important macro nutrients (carbohydrate, protein, fats) and minerals (such as Zn and Ca) which helps to fight against several diseases (e.g. diabetes, cardiovascular diseases, etc). Therefore, it is a good source of nutrients and could be recommended to be used as a supplement.

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PROXIMATE AND SENSORY PROPERTIES OF OGIRI- A TRADITIONAL CONDIMENT FROM PAW-PAW (*Carica papaya*) SEEDS

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Abstract

This study focused on the evaluation of pawpaw seed in the production of local condiment and its adoption as an inexpensive alternative source to alleviate protein malnutrition. Fresh pawpaw seeds obtained were sundried, cracked and winnowed to obtain the kernel and boiled for 3 h. The boiled pawpaw kernels were ground into a paste and wrapped in small portions with plantain leaves. The wrapped samples were fermented anaerobically in an air-tight container for 72 h, and likewise, castor oil seeds used as the control sample were treated in the same manner. Samples were analyzed every 24h for their proximate composition using standard procedure. Sensory properties were also carried out. From the study, moisture, protein, fat, and ash contents ranged from 45.1 to 46.79%, 15.80 to 17.49%, 31.05 to 31.94%, and 1.21 to 1.29% respectively. Fermentation process increased the proximate composition of the samples. The sensory evaluation conducted on the organoleptic qualities of the samples showed no significant ($p > 0.05$) difference in the overall acceptability of the fermented pawpaw seeds and the control sample. From the results obtained, it can be concluded that fermented pawpaw seeds can be used effectively as a substitute to castor seeds for the production of “ogiri” condiments.

Key words: Local Condiments, Pawpaw seeds, Protein malnutrition, ‘Ogiri’, Alkaline fermentation

Introduction

Condiments are preparation products supplemented in foods aimed at achieving specific desired changes in flavor or texture in the prepared food menu (Uzodinma *et al.*, 2021). Food condiments have been an important part of various cultural dishes appearing in different forms all over the world. Its consumption continues to increase due to population growth, increasing number of food-service outlets, growing consumer taste preferences and changing eating habit, amongst other reasons. African condiments, usually introduced during cooking in fairly small amounts are largely of pungent flavor. In Nigeria, ‘ogiri’ a popularly produced fermented local condiment obtained from either melon (*Citrullus vulgaris*), castor oil seed (*Ricinus communis*) or African locust bean (*Parkia biglobosa*) (Odibo *et al.*, 2021), is used as flavoring agent like bouillon cubes such as Maggi and Knorr in soups and vegetable dishes as it produces a strong pleasant aroma during cooking and serves as a nutritious non-meat protein substitutes. Despite the popularity of the ‘ogiri’ condiment as a flavoring agent particularly among rural and urban people, there still remains some stigma associated with it, that is, characteristic putrid odour, short shelf life and stickiness.

Likewise, the cost of production and purchasing of their substrates has increased. This has led to the research and trial of other relatively cheaper, available and unpopular seeds for usage. One of such potential substrates is the seeds of pawpaw fruit. Papaya seeds which are obtained from ripe pawpaw fruit account for about 14.3% of the weight of fresh pawpaw. They have important nutrients for proper functioning of the human health. The seeds have about 50.1% fat, 29.2% protein and 29% fiber. In addition, it is a good source of calcium, phosphorus and magnesium (Dakare *et al.*, 2011), and possesses antioxidant activity. The presence of anti-nutrients in the seed however, makes it unsuitable for direct consumption and usage. Hence it is discarded as waste material. Fermentation is one of the oldest methods of food processing and preservation. It enhances nutritional quality, leads to flavor enhancement, degrades anti-nutritional factors and improves protein digestibility and bioavailability of mineral elements such as calcium and phosphorus (Olasupo *et al.*, 2016). Fermentation of legumes has great potential as key protein and micronutrient source. Legumes and their respective seeds when fermented serve as strong condiments and are notable sources of protein, with useful minerals and phytochemicals beneficial to human health. The protein and mineral content of pawpaw seeds portends its adoption as an inexpensive alternative source to alleviate protein malnutrition and micronutrient deficiencies among traditional people living in developing countries like Nigeria, where the problem of protein deficiency is still a lingering issue till date. The objective of this work is to produce a local food condiment from pawpaw seeds using natural fermentation method of producing *ogiri*.

Materials and Methods

Pawpaw (*Carica papaya*) seeds were procured (1.5kg) from Department of Crop Science, University of Nigeria, Nsukka. Castor oil seeds (*Ricinus communis*) were procured (1kg) from Ogige market in Nsukka North LGA of Enugu State, Nigeria. *Ogiri* (*Ricinus communis* condiment) was prepared traditionally using the method outlined by Ibeabuchi *et al.* (2014). Castor oil (*Ricinus communis*) seeds were dehulled and then sorted to remove bad seeds and unwanted materials. The cotyledons were wrapped in blanched banana leaves and boiled for 8h to soften. Then, it was left to ferment at the prevailing ambient temperature (32-35°C) for 4 days. At the end of the fermentation period, the seeds were ground into a paste and wrapped up again into leaves and left near the fire places for one more day, when the unique aroma of 'ogiri' was expected to have developed and then dried in the oven.

Preparation of sample from pawpaw seeds using the traditional method

Fermented seeds were prepared using the method described by (Dakare *et al.*, 2011). Fresh seeds of *C. papaya* obtained were sun dried for one hour, cracked and winnowed to obtain the kernel. The seed kernels were boiled for 2-3 h, filtered and spread in a lined sack containing fresh pawpaw leaves, while still hot. The boiled pawpaw kernel was incubated at 37°C and allowed to ferment for 72 h. The fermented seeds were ground into paste using a manual hand grinder. The samples were determined for proximate composition and sensory properties using standard methods.

Results and Discussion

Table 1 shows the effect of fermentation time on the proximate composition of the fermented raw materials.

The moisture content of the fermenting raw materials ranged from 45.17-46.79% and 42.20-43.41 for samples A and B respectively. With sample A₀ and B₀ having the least moisture content and A₇₂ and B₇₂ the highest value. From the result, it can be deduced that as fermentation progressed, there was an increase in moisture content from 0 h to 72 h. According to Ahaotu et al.(2020), increase in moisture content as fermentation progresses could be attributed to the hydrolytic decomposition of the product during fermentation. There was significant ($p < 0.05$) difference among the samples. The protein content of the fermenting raw materials ranged from 15.80-17.49% and 21.74-23.25% for samples A and B respectively, with samples A₀ and B₀ having the least protein content and A₇₂ and B₇₂ the highest value. There was a gradual increase in the protein content as the fermentation time increased. There was no significant ($p > 0.05$) difference among the protein content of the samples at different fermentation time. The increase in protein content of the samples may be attributed to synthesis of enzymes and a degradation of the substrate during fermentation. The observed increase in protein content of the pawpaw seed is similar to that observed by (Dakare *et al.*, 2011). He reported that fermentation increased the protein content of pawpaw seed for the production of Daddawa from 21.72 to 23.56%. The ash content of the fermenting raw materials ranged from 1.08- 1.29% and 2.14-3.23% for samples A and B respectively, with samples A₄₈ and B₀ having the least ash content and A₇₂ and B₇₂ the highest value. The ash content for pawpaw seed was higher than that of castor seeds. Ash content significantly ($p < 0.05$) increased as fermentation increased from 0 h to 24 h and decreased at the 48 h but increased significantly again at 72 h. High ash content implies high mineral content. Ash content of food gives an idea of the total quantity of mineral elements in the food (Idowu and Abegunrin, 2014); it indicates the inorganic element after organic materials (fats, carbohydrates and proteins) and moisture are removed by oxidation or incineration (Hannington *et al.*, 2020). The carbohydrate content of the fermenting raw materials ranged from 1.55- 5.90% and 3.85-9.26% for samples A and B respectively, with samples A₇₂ and B₇₂ having the least ash content and A₀ and B₀ the highest value. There was a significant ($p < 0.05$) decrease in the carbohydrate content of the two samples as fermentation progressed. The apparent decrease may be attributed to increased activity of amylolytic enzymes which hydrolyze starch and other complex carbohydrate to simple sugars which provide energy for the fermenting microorganisms as a carbon source for the possible synthesis of other compounds. Previous research found that *Bacillus* spp. produce several enzymes including amylase, glucosidase and galactanase which degrade carbohydrates into simple sugars used as energy source by the microorganisms (Boateng *et al.*, 2014).

Table 1: Proximate composition of fermented castor seeds and pawpaw seeds used in ogiri production

Time	Sample	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
0 H	A	45.17 ^a ±0.01	15.80 ^a ±0.01	31.05 ^a ±0.02	0.87 ^a ±0.01	1.21 ^b ±0.01	5.90 ^{ab} ±0.01
	B	42.20 ^a ±0.01	21.74 ^a ±0.01	23.45 ^a ±0.01	1.21 ^a ±0.01	2.14 ^b ±0.01	9.26 ^{ab} ±0.00
24 H	A	45.65 ^a ±0.01	16.46 ^a ±0.01	32.14 ^b ±0.01	1.29 ^b ±0.01	1.25 ^a ±0.01	3.24 ^b ±0.02
	B	42.85 ^a ±0.01	22.45 ^a ±0.01	23.98 ^b ±0.01	1.29 ^b ±0.01	2.29 ^c ±0.01	7.14 ^{ab} ±0.05
48 H	A	46.29 ^a ±0.01	16.90 ^{ab} ±0.12	31.62 ^a ±0.01	1.01 ^a ±0.01	1.08 ^a ±0.01	3.10 ^{ab} ±0.12
	B	43.02 ^a ±0.01	22.98 ^{ab} ±0.01	23.78 ^a ±0.01	1.15 ^a ±0.01	2.16 ^a ±0.06	6.91 ^{ab} ±0.03
72H	A	46.79 ^b ±0.01	17.49 ^b ±0.01	31.9 ^{ab} ±0.01	0.94 ^a ±0.01	1.29 ^b ±0.01	1.55 ^a ±0.01
	B	43.41 ^b ±0.01	23.25 ^b ±0.00	25.14 ^b ±0.00	1.12 ^a ±0.01	3.23 ^b ±0.01	3.85 ^a ±0.02

Values are presented in mean $\pm$ standard deviation. Mean followed by difference superscript are significant difference from each other at $p < 0.05$ between the samples. A=Castor oil seeds, B=Pawpaw seed

Table 2 shows the average mean sensory scores of organoleptic properties of *nsala* soup prepared with *ogiri* from pawpaw and castor seeds.

The sensory scores for appearance ranged from 6.00 to 7.67 with sample B having the least score and sample C (soup prepared without addition of any of the condiment) having the highest score. Generally, all the samples were highly rated by the panelists as having a desirable appearance. In terms of appearance, samples A, and C were not significantly ($p > 0.05$) different in their appearance as rated by the panelists. Sample C was however more preferred compared to the other sample. Fermentation produced a slightly dark colour among the fermented samples which may be attributed to the activities of microorganisms on the substrate. Colour is one of the most important parameters in any new developed food product because it can affect the acceptability of the product. The sensory scores for aroma ranged from 7.20 to 7.93 with sample A having the least score and sample C (soup prepared without addition of any of the condiment) having the highest score. The aroma scores increased significantly ($p < 0.05$) between scores given to samples A and C with no significant differences between sample B and the other samples. In terms of taste, the panelists rated sample B lower than the other sample. There was no significant difference observed between samples A and C. Sample A was given the highest score of 7.93 and was most preferred by the panelists. The data obtained from the organoleptic properties of castor seeds and pawpaw seeds used in *ogiri* production showed that there were no significant ($p > 0.05$) differences between the samples. The scores were 7.80, 7.27 and 7.80 for A, B and C, respectively in terms of overall acceptability. Although no significant differences existed among the samples, panelists showed much preference for samples A and C which could be attributed to the fact that the test panelists were more familiar with the organoleptic properties.

Table 2: Sensory score for organoleptic qualities of Nsala soup prepared with ogiri from castor seeds and pawpaw seeds.

Sample	Appearance	Aroma	Odour	Flavor	Taste	Overall acceptability
A	7.40 ^b ±0.99	7.20 ^a ±0.68	7.47 ^b ±1.06	7.67 ^a ±0.62	7.93 ^b ±0.59	7.80 ^a ±0.41
B	6.00 ^a ±1.13	7.27 ^{ab} ±0.88	6.47 ^a ±1.30	7.00 ^a ±1.07	6.80 ^a ±1.42	7.27 ^a ±1.03
C	7.67 ^b ±1.23	7.93 ^b ±1.16	6.80 ^{ab} ±1.61	7.40 ^a ±1.64	7.73 ^b ±1.39	7.80 ^a ±1.21

Values are presented in mean $\pm$ standard deviation. Mean followed by difference superscript are significant difference from each other at $p < 0.05$ between the samples. A = Soup prepared with ogiri from castor oil seeds, B = Soup prepared with ogiri from pawpaw seeds, C = Soup without any of the local condiments.

Conclusion

Fermentation is a promising processing method to increase the utilization of pawpaw seed. From the study, it can be concluded that pawpaw seeds can be used as a substitute for castor seed for the production of ogiri condiment. This is seen from the fact that most quality and nutritional composition of the two types of ogiri showed no statistically significant ($p > 0.05$) difference between them.

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DETERMINATION OF MASS TRANSFER PARAMETERS IN DEEP-FRYING OF “ROBO”

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Abstract

In this investigation, the mechanism of mass (moisture and fat) transfer during deep-fat frying of ‘robo’ (fried melon cake) was studied. The plots of dimensionless concentration ratios against time were used to determine moisture transfer parameters (moisture diffusivity, moisture transfer coefficient, moisture transfer Fourier number, moisture transfer Biot number and activation energy) and fat transfer kinetic parameters (rate constants and activation energy) at different frying temperatures of 140, 155 and 170°C. All moisture parameters increased with frying oil temperatures except moisture transfer Biot number which decreased linearly with increase in temperature with correlation coefficient (R^2) ≥ 0.99 . There was also positive linear relationship between fat transfer rate constant and frying temperatures ($R^2 \geq 0.99$). An Arrhenius type of relationship was found between temperature and the effective moisture diffusivity and fat transfer rate constant ($R^2 \geq 0.99$) with activation energies values calculated as 25.66 and 42.18 kJ/mol, respectively. Both moisture loss and fat desorption after initial adsorption of 60 seconds were adequately modeled by the first-order kinetics adopted with high correlation coefficient (R^2) value and were time and temperature dependent as revealed by Arrhenius analysis performed on the experimental data.

Keywords: Activation energy, Arrhenius relationship, Deep-fat frying, ‘Robo’, Moisture and fat transfer.

Introduction

Fried melon cake (‘Robo’) is a local snack in Western Nigeria processed from the cake of wild watermelon (*Colocynthis citrullus* L.) popularly known as egusi among the populace after mechanical expression of its oil. It is a nutrient-rich snack that contains protein and some essential amino acids that could complement the cereal or starch-rich meals by supplying the necessarily needed proteins (Adeyeye *et al.* 2020). The processing involves roasting, sorting, cleaning, milling, kneading/oil expression, molding, frying and packaging.

Immersion frying or deep-fat frying is an important step in the processing of fried melon cake. It is a process that involves desirable improvement in the eating qualities (organoleptic characteristics) such as smooth mouth feel, distinct flavor, color, texture, and palatability of foods (Franklin *et al.* 2013). According to Franklin *et al.* (2013), deep-fat frying is a cooking process that involves both simultaneous heat and mass transfer process in which food is immersed in edible oil at a temperature above the boiling point of water contained in that

food (Farinu and Baik 2005). By convection, heat is transferred from the hot oil to the food surface and through the body to the centre through conduction. As the product approaches the boiling temperature of water, moisture vaporizes and exits the product by diffusion, while fat enters or leaves the food product to or from the surrounding medium depending on whether the food is non-fatty or fatty foods.

Presently, 'robo' is traditionally produced in batches using rudimentary utensils and thus, the processing needs to be upgraded to standard level that will encourage full commercialization. The fundamental knowledge of mass (moisture and fat) transfer parameters as functions of temperature cannot be overemphasized in designing, modeling and process optimization of deep-fat frying of foods (Mosavian and Karizaki 2012).

Therefore, the objective of this present study was to determine mass (moisture and fat) transfer parameters such as effective moisture diffusivity (D_m), activation energy (E_a), moisture transfer Biot number (N_{Bi}), moisture transfer coefficient (k_m) and rate constant (k) of DFF of 'robo' at different frying temperatures.

Materials and Methods

Preparation of the melon meal balls and frying experiments

The traditional method as described by Adeyeye *et al.* (2018) was adopted in the preparation of 'robo' (fried melon cake). Deep-fat frying experiments were performed according to the method described by Franklin *et al.* (2013) and with some modifications. A thermostatically-controlled mini fryer of 3-L oil capacity heated by 2-kW electric coils at the bottom of oil tank pre-set at 140, 155 and 170 ± 2 °C with no agitation was used for all frying experiments. Commercial soybean oil obtained from a supermarket in Ogbomoso was added to augment the expressed oil from melon to make up required volume for frying experiments. Twenty pieces of melon meal balls each of melon meal balls were immersed into 3000 ml hot oil at different temperatures to give an average oil-to-melon meal balls ratio of 12.5 to avoid fluctuations in oil temperatures when the melon meal balls were first introduced into the oil and throughout the experimentations. The melon meal balls were submerged with the help of a stainless-steel basket, which was covered with a grid of the same material to ensure total immersion of the samples. The oil temperatures were ascertained to be at each pre-set conditions by inserting a stainless-steel k-type thermocouple probe into the oil. The temperature of the oil was recorded at 10-seconds interval throughout the experiments (10 minutes) through K-type thermocouples connected to a data acquisition system (INTECH Micro 2100-A16 Rev 1.3) and a PID controller (RKC HA 900 Instrument). Oil in the oil bath was replaced after one hour of frying so that the oil properties will not be significantly different throughout the experiments.

Samples for determination of moisture and fat contents of FMCs were removed at 30-s interval for the first 2 minutes, followed by 60-s (8 minutes) and 60 seconds interval. Oil adhering to fried MMCs were allowed to drain out in a stainless-steel wired basket lined with tissue paper immediately after frying.

Determination of moisture and fat contents

Whole fried melon cakes were collected at different time intervals were grounded separately in a mortar with pestle. The moisture and fat contents of the samples at different time intervals were determined using air-convective oven drying method and Soxhlet fat extraction method, respectively (AOAC, 2005).

Model Development

Model Assumptions

The followings were assumed for the development of mathematical models to simplify for analytical solution:

- The initial moisture and fat contents of fried melon cakes were uniform throughout the sample.
- The sample was homogeneous, isotropic, and spherical with constant dimensions throughout frying.
- One-dimensional unsteady-state mass transfer was in the radial direction.
- No internal heat generation in the product.

Determination of moisture transfer data

The partial differential equation modeling diffusion of water in solids as a function of time and location in a spherical coordinate (Bird et al., 2001; Franklin et al., 2013) was:

$$\frac{\partial m}{\partial t} = D_m \left(\frac{\partial^2 m}{\partial r^2} + \frac{2}{r} \frac{\partial m}{\partial r} \right) \quad (1)$$

where, D_m and r are moisture content, effective moisture diffusivity (m^2/s) and radial distance from the centre of food sample. The following were the initial and boundary conditions:

$$m = m_i, \text{ at } t = 0 \text{ for all } r; \frac{\partial m}{\partial r} = 0 \text{ at } r = 0; D_m \frac{\partial m}{\partial r} = k_m (m_t - m_o) \text{ at } r = R \text{ for } t \geq 0 \quad (2)$$

where “ m_i ” was the initial moisture content, “ m_t ” was the moisture content with respect to time, “ m_o ” was the moisture content of oil and “ k_m ” was the moisture transfer coefficient. The first term of infinite analytical solution of Eq. (1) suffices if the moisture transfer Fourier number ($N_{Fo} = \frac{k D_m t}{r_o^2}$) is greater than 0.1 as simply expressed by Eq. (3):

$$\frac{m(r,t) - m_o}{m_i - m_o} = \frac{\left(\frac{\sin(r_o \mu_1)}{\mu_1^2} - \frac{r_o \cos(r_o \mu_1)}{\mu_1} \right)}{\left(\frac{r_o}{2} - \frac{\sin(2r_o \mu_1)}{4\mu_1} \right)} \times \frac{\sin(r \mu_1)}{r} e^{-D_m \mu_1^2 t} \quad (3)$$

$$MR = \beta e^{-\gamma t} \quad (4)$$

where, MR , β and γ are the dimensionless moisture ratio, lag factor and frying coefficient (s^{-1}), respectively

$$MR = \left(\frac{m_t - m_o}{m_i - m_o} \right), \quad (5)$$

$$\beta = \frac{6(\sin(r_o \mu_1) - r_o \mu_1 \cos(r_o \mu_1))^2}{(r_o \mu_1)^3 (r_o \mu_1 - \sin(r_o \mu_1) \cos(r_o \mu_1))} \quad (6)$$

$$\text{and } \gamma = D_m \mu_1^2 \quad (7)$$

Taking the natural logarithm of both sides of Eq. (8) to linearize the equation as follows:

$$\ln MR = \ln \beta - \gamma t \quad (8)$$

$$\text{or } \ln \left(\frac{m_t - m_o}{m_i - m_o} \right) = \ln \frac{6(\sin(r_o \mu_1) - r_o \mu_1 \cos(r_o \mu_1))^2}{(r_o \mu_1)^3 (r_o \mu_1 - \sin(r_o \mu_1) \cos(r_o \mu_1))} - D_m \mu_1^2 t \quad (9)$$

Plotting $\ln MR$ against time, the intercept and the slope of the graph are equated to $\ln \beta$ and $-D_m \mu_1^2$, respectively. Two-step determination of the effective moisture diffusivity was carried out, firstly from the intercept of $\ln (MR)$ versus time plot, β (lag factor) from Eq. (10), the first root of the characteristic equation (μ_1) was calculated. Secondly, from the slope (frying coefficient) of the same plot, the effective moisture diffusivity was determined (Eq. 10). Dimensionless mass transfer Biot number and mass transfer coefficient were calculated from the analytical solution of the first term of Eq. (1) as:

$$Bi = 1 - r_0 \mu_1 \cot(r_0 \mu_1) = \frac{k_m r_0}{D_m} \quad (10)$$

Determination of fat transfer data

Oil transport was modeled according to the method adopted by Franklin *et al.* (2013) using the fractional conversion first-order reaction kinetic model with some modifications as expressed below:

$$\frac{f_t - f_e}{f_i - f_e} = k_o \exp - kt \quad (11)$$

where, “ f_t ” was the average fat content at any given time, (gfat/gDM), “ f_i ” was the average initial fat content, (gfat/gDM), “ f_e ” was the equilibrium fat content i.e., fat content at the end of frying at 170°C (minimum), “ k ” was the reaction rate constant (s^{-1}) at a particular temperature, k_o was the frequency factor (/s) and “ t ” was the frying time (seconds). The first order kinetic model was used because the plot of concentration of fat content of fried melon cakes against time is logarithmic in nature which is typical of first order processes. The temperature dependence of rate constant was described using the Arrhenius relationship:

$$\ln k = \ln k_o - \frac{E_a}{R_g} \left(\frac{1}{T} \right) \quad (12)$$

where, k_o is the frequency factor (/s), E_a is the activation energy, (kJ/mol) and R_g was the universal gas constant (8.314×10^{-3} kJ/mol K).

Results and Discussion

Calculated moisture transfer coefficient values are shown in Table 1 which ranged from 8.09 to 13.09×10^{-6} m/s within the temperature range investigated. These are similar to those reported by Dincer (1996), Franklin *et al.* (2013) and Mosavian and Karizaki (2012) for deep-fat frying of potato (5.98×10^{-7} m/s), *gulabjamun* ($10.41 - 14.35 \times 10^{-6}$ m/s) and rice crackers ($5.51 - 9.31 \times 10^{-6}$ m/s), respectively. Mass transfer coefficient during deep-fat frying of fried melon cake increased with frying temperatures within the domain investigated. The temperature dependency of moisture transfer coefficient was evaluated and there is linear relationship between the variables as it is validated by high correlation coefficient ($R^2=0.993$) as expressed by Eq. (13):

$$k_m = 1.67 \times 10^{-7} T - 1.54 \times 10^{-5} \quad (13)$$

Table 1 also shows the outcomes of the determination of moisture transfer Biot number which decreased linearly with increase in temperature range investigated. The values are consistent with those in existing literatures (Franklin *et al.* 2013; Kashaninejad *et al.* 2007; Mosavian and Karizaki 2012; Yildiz *et al.* 2007).

The thermal dependency of moisture transfer Biot number is as expressed by Eq. (14):

$$N_{Bi} = 8.48 \times 10^{-4} T - 1.11 \quad (0.999) \quad (14)$$

These values fall within the range for finite internal and external restriction to moisture transfer i.e., Biot number of 0.1 and 100 (Singh and Heldman 2009).

Table 1 Moisture transfer parameters for deep fat frying of ‘robo’ (FMC)

Temperature (°C)	D_m ($\times 10^{-7}$ m ² /s)	N_{Fo}	N_{Bi}	k_m ($\times 10^{-6}$ m/s)
140	1.019	0.392	0.992	8.09

155	1.287	0.492	0.980	10.09
170	1.692	0.649	0.967	13.09

Fat transfer parameters

Table 2 Arrhenius model parameters for moisture and fat transfer of deep-fat frying of 'robo'

Temperature (°C)	Moisture transfer			Fat transfer			
	$D_o(m^2/s)$	$E_a(kJ/mol)$	R^2	$k (/s)$	$k_o(/s)$	$(E_a)(kJ/mol)$	R^2
140				0.0023			
155	-8.64	25.66	0.996	0.0031	6.16	42.18	0.96
170				0.0053			

Fat transfer parameters of *robo* as exuded by chemical kinetics and as affected by frying temperatures are as shown in Table 2. The fat depletion increased throughout the time of frying at all temperatures the initial uptake up to 60 seconds. The decrease was logarithmic in nature and therefore, follows a first-order kinetics (Singh and Heldman 2009). The final fat content was inversely proportional to the frying temperature, which was consistent with the results for donuts, for *gulabjamun* (Franklin *et al.* 2013). According to Franklin *et al.* (2013), low frying temperatures and thus weak water outflow led to the formation of surface crust with a structure more favorable to oil absorption. In other words, higher frying temperatures produced harder and tougher crust, promoting an increased resistance and reduced surface diffusivity for fat adsorption. The fat desorption at all temperatures was adequately described by fractional conversion first-order kinetics ($R^2 \geq 0.986$). The activation energy for loss of fat was calculated as 42.12 kJ/mol. The rate constant increased from 2.33×10^{-3} to 5.52×10^{-3} /s as the frying temperature increased from 140 to 170°C (Table 2). This trend was contrary to the outcomes of Franklin *et al.* (2013) that the rate constant decreases as the frying temperature increases. It could be attributed to desorption which happened for larger period of frying rather than the adsorption that was reported by these investigators. However, as expected in both cases, higher temperatures resulted into low final moisture and fat contents which was corroborated by the works of other investigators (Sosa-Morales et al. 2006; Taiwo et al. 2007).

4. Conclusion

In this work, mass transfer during deep-fat frying of *robo* was investigated by experimental and analytical methods to determine parameters for process design. The method is based on the measurement of the time-dependent moisture and fat contents of the dough employing Fick's second law equation for 'robo' dough geometry (spherical shape) and fractional conversion first-order kinetics, respectively. The moisture transfer parameters determined increased except Biot number which decreased with increase in temperature and all have linear relationship with temperatures within the domain investigated. The fat desorption after initial adsorption of 60 seconds was adequately modeled by the fractional conversion first-order kinetics adopted with high correlation coefficient (R^2) value and was time and temperature dependent as revealed by Arrhenius analysis performed on the experimental data.

Conflict of Interest

The authors have no conflicting interests, financial or otherwise.

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INVITRO RADICAL SCAVENGING CHARACTERISTICS OF PURIFIED COIX SEED PEPTIDES

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Abstract

The aim of this study was to isolate, purify and evaluate the radical scavenging properties of coix seed peptides. Coix seed peptides were isolated using 100, 30, 10, 5, 3 and 1 kDa ultrafiltration membranes after ultrasound-assisted enzymolysis using trypsin. The resulting peptide that demonstrated the highest radical scavenging activity (CSPH-1, MW<1) was separated by Sephadex gel filtration into three fractions namely CSPH-1A, CSPH-1B and CSPH-1C. 1,1-diphenyl-2-picrylhydrazyl (DPPH), hydroxyl radical scavenging activity (HRSA) and ferrous chelating (FRAP) activity were used to assay the peptide molecular weight fractions and gel filtration fractions. The results of the study showed that MW<1 (CSPH-1) exhibited the highest radical scavenging rate. CSPH-1C demonstrated the highest radical scavenging rate with IC₅₀ values of 1.37 mg/ml, 0.44 mg/ml and 2.73 mg/ml for HRSA, DPPH and FRAP respectively. The results of this study suggest that coix seed peptides could act as functional ingredient with antioxidant properties against reactive oxygen species (ROS).

Keywords: Coix seed, Peptides, Antioxidants, Oxidative stress, Purification

Introduction

It is generally known that oxidative stress occurs when there is an imbalance between the production (reactive oxygen and nitrogen species) and neutralization (antioxidants) of free radicals in favour of the former. The emergence and progression of non-communicable diseases (including diabetes, cancer, premature aging, and cardiovascular diseases among others) is a consequence of the excessive production of reactive oxygen species which induces oxidative damage to cell membranes and biological molecules. Reactive oxygen species (ROS) can be successfully removed by the antioxidant defense system under normal physiological conditions (Nita and Grzybowski, 2016). However, under pathological conditions, there is an imbalance in the production and clearance of ROS, which causes cell death or damage. Therefore, several studies revolving around plant-derived antioxidant peptides including corn, mung bean (Sonklin et al., 2021), cotton seed (Wang et al., 2021), water melon seed (Wen et al., 2019) among others have been undertaken over the last decade in order to boost the human endogenous antioxidant system, thereby improving overall health. These plant-derived antioxidant peptides could be successfully utilized as food additives and pharmaceutical excipients. Presently, coix seed protein-derived antioxidant peptides are less reported in literature. Coix seed (*Coix lacryma-jobi* L.) is a tropical Asian cereal grain that is mostly used for food or used as herbal remedy. As a bioactive food, it has been found to exert a variety of biological functions both in vivo and invitro including anti-cancer, anti-inflammatory, and antioxidant properties, among others. According to Liu *et al.*, (2015), coix seed has the following nutritional value: fat 5.14–9.40%, protein 12–14%,

carbohydrate 65%, 3% crude fiber, 0.242% phosphorus, 0.07% calcium. The oil component of coix seed, which plays a significant functional role in cancer therapy and treatment, has driven its demand to soar over the past few years. In our previous study, the structural and morphological modifications of coix seed protein isolate were explored (Igbokwe, *et al.*, 2022). Herein, this paper aims to prepare bioactive peptides from coix seed meal by ultrasound-assisted enzymatic hydrolysis and evaluate the *in vitro* radical scavenging activity of purified peptides.

Materials and Methods

Coix seed was purchased from a local market in Zhenjiang, China. Trypsin was procured from Novozymes Co. Ltd. (Tianjin, China). Ultrasonic-assisted enzymatic method was adopted for the preparation of coix seed protein hydrolysates (CSPHs). Defatted coix seed meal (40 g/L) was hydrolysed using trypsin enzyme with pre-determined optimum conditions of enzyme dosage (4000 U/g), hydrolysis time (90 min), reaction pH (8), and hydrolysis temperature (50 °C) assisted with an ultrasound device (Jiangsu University Five Pines Biotechnology Co., Ltd Zhenjiang, China) with ultrasonic power density: 100 W/L; frequency: 20 kHz, pulse duration: on-time, 5s: off-time, 1s. Sodium hydroxide (NaOH 1M) was used to maintain the optimum pH of the reaction. Then, the enzymatic reaction was terminated by boiling the sample at 100 °C for 10 min, then cooled (25 °C) before adjusting the pH to 7 with HCl (1M) and centrifuged (8000 g, 10 min). The supernatant was collected for ultrafiltration. Samples were sequentially fractionated by ultrafiltration, using cellular membranes with 100, 30, 10, 5, 3 and 1 kDa molecular weight cutoff (MWCO; Millipore, U.S.A.). The obtained peptide fractions were concentrated and lyophilized, then stored (-20 °C) for subsequent analysis. The peptide fractions were assessed for *in vitro* antioxidant activity. The fraction with the highest antioxidant activity was subsequently purified with Sephadex gel filtration. A 0.22 µm aqueous membrane was used to filter CSPH-I (20 mg/mL). Then, 5 mL of the sample solution was loaded onto a well-balanced Sephadex G-15 column (100 cm × 1.6 cm), and different fractions were collected by an automatic fraction collector at a flow rate of 1 mL/min. Besides, in order to obtain the elution curve of the sample solution, the absorbance of each tube solution was measured at 280 nm (Tecan instrument, Australia). The same elution peak fractions were pooled and lyophilized to measure the levels of 1,1-diphenyl-2-picrylhydrazyl (DPPH), hydroxyl radical scavenging activity (HRSA) and ferric reducing antioxidant power (FRAP) according to the methods of (Adjimani and Asare, 2015; Zhang *et al.*, 2018; Zhu *et al.*, 2019) respectively using different concentrations of 2, 1, 0.5, 0.25 mg/mL. The experiment was conducted in triplicate (n=3) measurement and results were analyzed and given as mean ± standard deviations. All graphs were fitted using OriginPro 8.5 software (Northampton, MA, USA).

Results and Discussion

Purification of coix protein hydrolysates

Ultrafiltration is a technique which involves the separation of molecular species on the basis of size, shape, and/or charge through a semi-permeable membrane by means of hydrostatic pressure. Ultrafiltration technique fractionated coix seed protein hydrolysates into six fractions with different molecular weights namely 100 – 30 kDa, 30 – 10 kDa, 10 – 5 kDa, 5 – 3 kDa, 3 – 1 kDa and < 1 kDa as shown in Fig. 1. The antioxidant potency of fractionated CSPH increased as the molecular weight decreased, with the highest level of antioxidant activity been exhibited by peptides with a molecular weight of < 1 kDa. This may be attributed to the fact that peptide fractions with lower average molecular weight have the potential to transform free radicals to more stabilized forms and impede the reaction. Furthermore, it has been reported that lower molecular weight peptides have free access to lipid radicals, which in effect, eliminate these free radicals (Ngo and Kim, 2013). Additionally, they have high levels of aromatic and hydrophobic amino acids, which enhances their antioxidative capacity. Higher molecular weight peptides, on the other hand, exhibit weaker scavenging potency as a result of the steric hindrance they generate (Hwang et al., 2016).

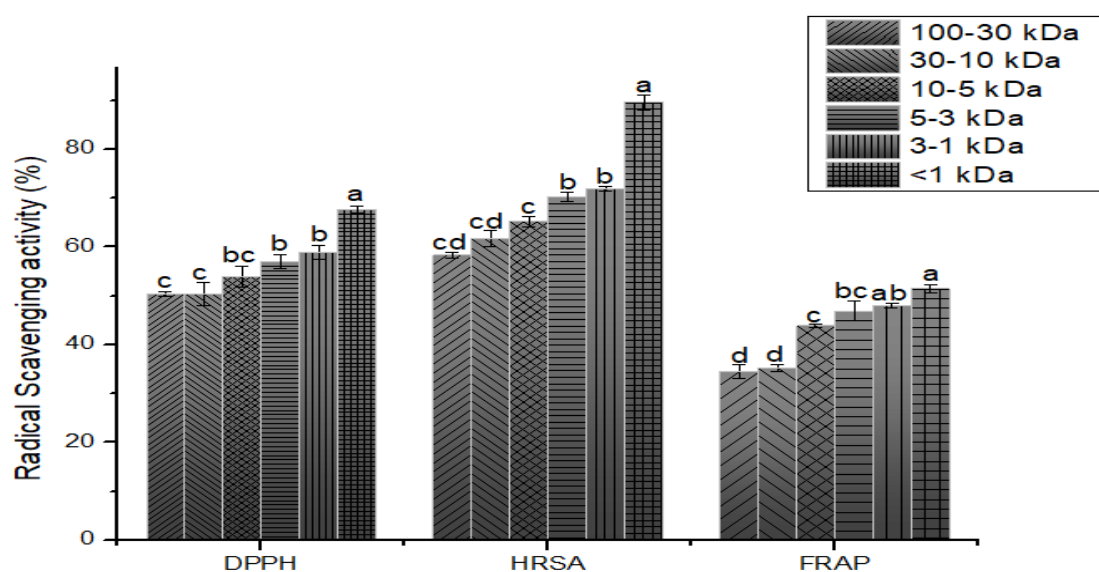


Fig 1: Radical scavenging activity of ultrafiltered coix seed peptides

The fraction CSPH-1 (MW < 1) with the highest antioxidative activity was further subjected to gel filtration. Gel filtration exploits the differences in molecular size to achieve separation, molecules are eluted in decreasing molecular size. Gel filtration separated the samples into three fractions namely: CSPH-1A, CSPH-1B, CSPH-1C (Figure 2a). Sub-fraction CSPH-1C displayed the most potent antioxidant activity (IC_{50} value = 2.73 mg/ml, 0.47 mg/ml and 1.37 mg/ml) as shown in Fig 2b for ferrous chelating (FRAP), 1,1-diphenyl-2-picrylhydrazyl (DPPH) and hydroxyl radical scavenging activity (HRSA) respectively among the three sub-fractions. The lower the IC_{50} value of a sample, the more potent the activity of the substance.

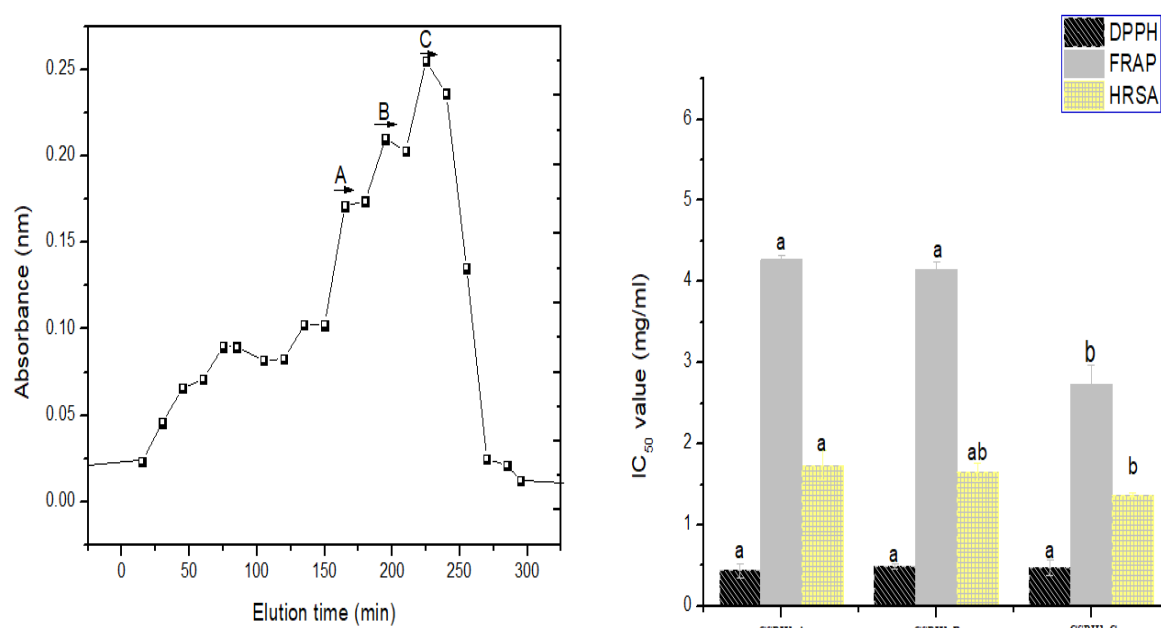


Fig 2a: Gel filtration chromatogram of CSPH-1; Fig 2b; Antioxidant profile of sub-fractions of CSPH-1 (MW<1)

Conclusion

Coix seed protein peptides were prepared using ultrasound-assisted enzymolysis. Ultrafiltered fractions with molecular weight <1 kDa displayed maximum radical scavenging activity. CSPH-1, a sub fraction derived from gel filtration had the strongest antioxidant activity. The results obtained from the study may provide baseline data for its application as natural antioxidant agent in the food industry.

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COMPARATIVE NUTRITIONAL COMPOSITION OF ROSEMARY HERB WITH SELECTED INDIGENOUS SPICES (*GBAFILO*/COCOPLUM AND *NJANGSA*)

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Abstract

With rising prevalence of nutrition-related diseases and food scarcity there is need to study and utilize lesser-known, healthful and nutritious plant foods in food production. Spices and herbs are nutritious and bioactive plant materials that are incorporated in the diet. The nutritional composition of two local culinary spices: Cocoplum (*Gbafile*) (*Chrysobalanus icaco*) and *Njangsa* (*Ricinodendron hendelotii*) were compared with Rosemary (*Rosemarinus officinalis*). They were analyzed for their proximate and micronutrient compositions. There were significant differences in the proximate and micronutrient composition of the samples. The proximate parameters were found to range from 5.50-8.60%; 11.20-31.17%; 11.77-40.34 %; 8.17-18.29 %; 5.30-14.59 % and 16.32-38.63 % for moisture, protein, fat, fiber, ash and carbohydrates respectively. Fat and protein contents were highest in *Njangsa*, and cocoplum respectively, while Rosemary had the highest ash and fiber contents. The micronutrient composition ranged as follows: iron(3.05-10.9)mg/100g; magnesium(130.8-638.28)mg/100g; copper(0.00-0.22)mg/100g; zinc(0.76-4.68)mg/100g; calcium(220-1060)mg/100g; sodium (243.73-475.09)mg/100g; phosphorous(62.88-310.16)mg/100g; vitamin A(162-1011)mg/100g; vitamin B1 (0.20-0.31)mg/100g; vitamin B2(0.01-0.46)mg/100g; vitamin B3(0.142-4.66)mg/100g; vitamin B9(3.90-53.00)mg/100g; vitamin C(54.34-73.65)mg/100g and vitamin E(0.21-24.93)mg/100g. *Njangsa* had higher magnesium, calcium and phosphorous, while rosemary contained more vit C., zinc and iron. Generally, the three spices were nutritious and should be utilized more in the diet and development of food supplements and nutraceuticals.

Keywords: Cocoplum, *Njangsa*, Rosemary, Proximate, Micronutrients

Introduction

In the face of increasing number of health-conscious consumers and food scarcity, there is need to explore lesser-known, but nutritious plant foods with enhanced health benefits. Culinary herbs and spices besides being important sources of nutrients are also powerful sources of antioxidants, antimicrobials, antidiabetic, chemoprotective and anti-inflammatory compounds and are used to alleviate the symptoms of several ailments (Kassahun and Feleke, 2019). They form an important part of most Nigerian savory dishes. They are also used as local elixir in the management of certain ailments. Increasing the consumption of culinary herbs and spices could help in the alleviation of some micronutrient deficiencies and their associated health problems. Rosemary is an aromatic herb native to the Mediterranean region and belonging to the family, Lamiaceae and genus, *Rosmarinus*. It is widely used globally for medicinal, culinary, and ornamental purposes.

Rosemary (*Rosemarinus officinalis*) contains nutrients such as iron, calcium, and B-vitamins. *Chrysobalanus icaco* belonging to the family Chrysobalanaceae is a lesser-known plant native to northern South America and West Africa. The seed of *Chrysobalanus icaco* has a unique almond-like flavor. It is roasted and used as a spice flavoring in soups and jellies and the fresh skin of the fruit used for jams and jelly in South America. It is used in traditional medicine in some countries like Mexico and Brazil. *Ricinodendron heudelotii* commonly known as Honeyplum is a lesser-known wild tree plant native to Sub-Saharan Africa. The seeds of *Ricinodendron heudelotii* have several culinary applications as pepper soup spice and thickener in soups and stews in West and Central Africa. The oil in the seeds can be extracted and used in cooking. *Chrysobalanus icaco* is a rich source of micronutrients and phenolics such as potassium, magnesium, calcium, sodium, flavonoids, diterpenes and triterpenes (Onilude *et. al.*, 2020). *Ricinodendron heudelotii* seed extract has polyunsaturated fatty acid similar to that of fish (USDA, 2016) with high protein (30%) and mineral content (Ene-Obong *et. al.*, 2018). *Chrysobalanus icaco* and *Ricinodendron heudelotii* have been shown to have good antioxidant capability (Ene-Obong *et. al.*, 2018). *Njangsa* (*Ricinodendron heudelotii*) and *Gbafilococoplum* (*Chrysobalanus icaco*) are inexpensive and readily available in local markets in Nigeria. Increasing their consumption by adding them to stews, soups and sauces could contribute to increased nutrient intake, reduction in micronutrient deficiencies and alleviation of certain inflammatory and metabolic diseases in the population. This study was conducted to comparatively evaluate the nutritional composition of Rosemary, *Gbafilo* and *Njangsa* spices.

Materials and Methods

The spices, *Chrysobalanus icaco* (*Gbafilo*), *Rosemarinus officinalis* (Rosemary) and *Ricinodendron heudelotii* (*Njangsa*) were purchased fresh from retailers at a local market, Eke Awka, Awka, Anambra State. Authentication of the spices was done at the Taxonomy Unit of the Department of Botany, University of Nigeria, Nsukka. Analytical grade reagents were used for the chemical analyses. *Gbafilo* and *Njangsa* were cleaned to remove extraneous materials and impurities. *Chrysobalanus icaco* was dehulled to expose the fleshy seed. They were then milled to 0.05mm particle size, packaged in glass containers and stored in the freezer until used. The proximate, mineral and vitamin compositions were analyzed using the methods of AOAC (2006). All determinations were done in triplicates. The data was analyzed statistically using statistical software SPSS (version 21)

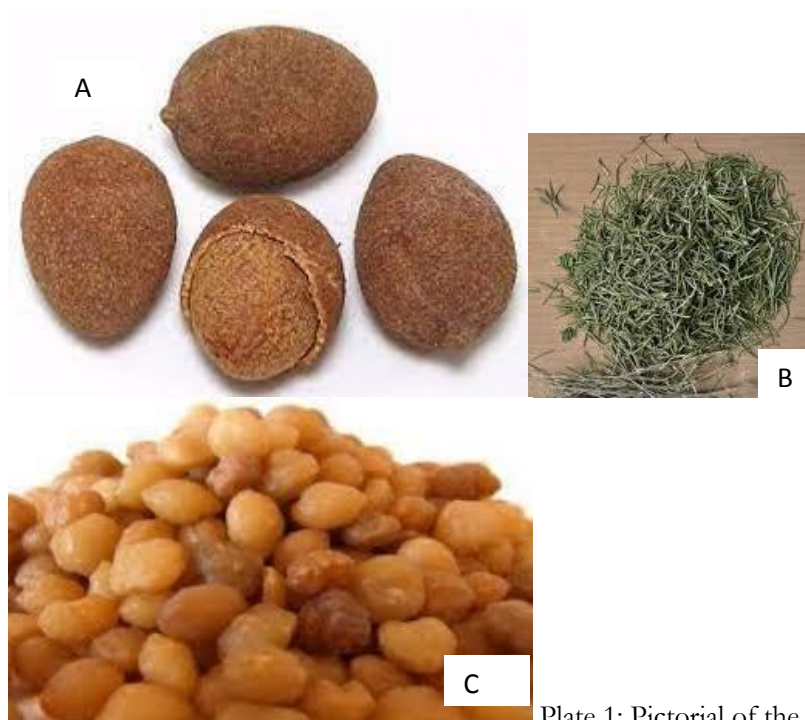


Plate 1: Pictorial of the herb and spices used in the study

(A= Cocoplum; B = Rosemary and C= *Njangsa*)

Results and Discussions

There were variations in the moisture, protein, fats, fibre, ash and carbohydrates contents (dwb) of the different herbs and spices studied ($p < 0.05$) (Table 1). Moisture and protein contents ranged from 5.50 to 8.60% and 11.20 to 31.17%, respectively, with cocoplum having the highest values. The spices and herbs are sold and used in their dry states, hence the low moisture contents. Proteins reserves of plants are usually higher in the seeds than in the leaves which could have resulted to the significantly ($p < 0.05$) higher protein values contents of the spices compared with the rosemary herb. The high protein content of cocoplum is comparable to the values (25-30%) found in high proteinous seeds such as hemp seeds (Leonard *et al.*, 2020). Addition of cocoplums in meals could contribute to increased protein intake in the diet. Fats content ranged from 11.77 to 40.34 %, with the highest value recorded in *Njangsa* spice. *Njangsa* is a high oil seed with the value obtained similar to the results of USDA (2016). The lipids in *njangsa* contain high polyunsaturated fatty acids, with about 56% of conjugated linolenic acid and 40 % content of omega-3 fatty acids which are similar to that found in fish oil (USDA, 2016). The mean value obtained for fats in *njangsa* was a bit lower than that reported by Ene-Obong *et al.*, (2018). Fiber and ash contents ranged from 8.17 to 18.29 % and 5.30 to 14.59 %, respectively, with rosemary having the highest values. The high fiber and ash values of rosemary sample were comparable to results gotten by Lister (2007) and Kassahun and Feleke (2019). Fiber in the diet helps to regulate blood sugar, reduce risks of hypertension and improve bowel movement. Carbohydrate content ranged from 16.32 to 38.63 %. Ash content of food materials is related to the quantity of inorganic materials and minerals contained in them.

Table 1: The proximate composition of Rosemary herbs and njangsa and cocoplum spices

Common name of culinary Spices/herbs	Protein (%)	Moisture (%)	Fats (%)	Fibre (%)	Ash (%)	Carbohydrates(%)
<i>Njangsa</i>	20.85 ^b ± 0.60	7.38 ^b ± 0.40	40.34 ^c ± 0.75	9.77 ^a ± 0.93	5.30 ^a ± 0.65	16.32 ^a ± 1.58
Cocoplum/ <i>Gbafilo</i>	31.17 ^c ± 1.07	8.60 ^c ± 0.53	20.33 ^b ± 0.47	8.17 ^a ± 0.60	7.12 ^b ± 0.19	24.61 ^b ± 1.61
Rosemary	11.20 ^a ± 0.82	5.50 ^a ± 0.26	11.77 ^a ± 1.10	18.29 ^b ± 0.88	14.59 ^c ± 0.45	38.63 ^c ± 1.86

Values are expressed as means of triplicates ± standard deviation. Values in down the same column with the same superscript are not significantly different (p<0.05).

From Fig 1, the micronutrient composition of the samples ranged as follows: iron (3.05-10.9) mg/100g; magnesium (60.28-317.63)mg/100g; copper (0.00-0.22) mg/100g; zinc (0.76-4.68) mg/100g; calcium (220-529.37)mg/100g; sodium (14-37)mg/100g; phosphorous (62.88-310.16)mg/100g; vitamin A (101.42-172.54)IU/100g; Vitamin B1 (0.20-0.31) mg/100g; Vitamin B2 (0.01-0.46)mg/100g; Vitamin B3 (0.142-4.66)mg/100g; Vitamin B9 (3.90-5.00)mg/100g; Vitamin C (54.34-73.65)mg/100g and Vitamin E (24.93-300.93)IU/100g. The values all significantly differed (p<0.05) among all the samples. *Njangsa*, had the highest amount of calcium (529.37 mg/100g), vitamin A (172.54mg/100g), sodium (37.54mg/100g), magnesium (317.63mg/100g), phosphorous (310.16mg/100g) and vitamin E (300.93 IU/100g). The calcium, Vitamin A, sodium, magnesium, phosphorous and vitamin E in 100g of *njangsa* offers up to about 50%, 15%, 2.27%, 79%, 24.8% and 75% respectively, of the recommended daily allowance (RDA) for all ages. Oil seeds are usually the major plant sources of vitamin A and E. On the other hand, rosemary contained significantly (p<0.05) higher quantities of iron (10.97 mg/100g), copper (0.22 mg/100g), zinc (4.68 mg/100g), vitamin B1 (0.17 mg/100g), vitamin B2 (0.46 mg/100g), vitamin B3 (4.66 mg/100g), vitamin B9 (5.0 mg/100g) and vitamin C (73.65 mg/100g). The rosemary sample contained about 50%, 24%, 42.54%, 14%, 35.38%, 29%, 0.8% and 81% of the recommended dietary allowance for iron, copper, zinc, vitamin B₁, vitamin B₂, vitamin B₃, vitamin B₉ and vitamin C for most age groups. Vitamin A is nutritionally relevant for sight, cell recognition, immune function and reproduction. The B-vitamins function as co-enzymes and are important in macronutrient metabolism and cell transport. Vitamin E aids in the prevention of inflammation, supports immune function and improves good sight. The dietary minerals are important for several cellular and immune functions, as well as growth and development. Rosemary, *njangsa* and cocoplum are nutritionally important plant foods. Their use in preparation of meals and production of nutraceuticals and food supplements should be encouraged. The micronutrient results obtained in the study are similar to those obtained by Ezekwe *et al.* (2014), Lister (2007), Ene-Obong *et al.*, (2018), Okonkwo and Ogu (2014) and Aguiara *et al.*, (2017).

Conclusion

Njangsa, *Cocoplum*(*Gbafilo*) and Rosemary showed appreciable, but significantly varied composition of macro and micronutrients. *Njangsa*, had the highest amount of fats (40.34%), calcium (529.37 mg/100g), vitamin A (172.54mg/100g), sodium (3754mg/100g), magnesium (317.63mg/100g), phosphorous (310.16mg/100g) and vitamin E (300.93 IU/100g). *Cocoplum* had the highest amount of protein (31.17%), moisture (8.60%), On the other hand, rosemary contained significantly ($p < 0.05$) higher quantities of fiber (18.29%), ash (14.59%) and carbohydrates (38.63%), 1ron (10.97 mg/100g), copper (0.22 mg/100g), zinc (4.68 mg/100g), vitamin B1 (0.17 mg/100g), vitamin B2 (0.46 mg/100g), vitamin B3 (4.66 mg/100g), vitamin B9 (5.0 mg/100g) and vitamin C (73.65 mg/100g). Optimum nutritional benefits might be derived by blending the spices and herbs together in various proportions and using them in meal preparations. They also be used in the development of food supplements and nutraceuticals. The increased consumption of herbs and spices should be encouraged to combat the burden of micronutrient and macro-nutrient deficiencies.

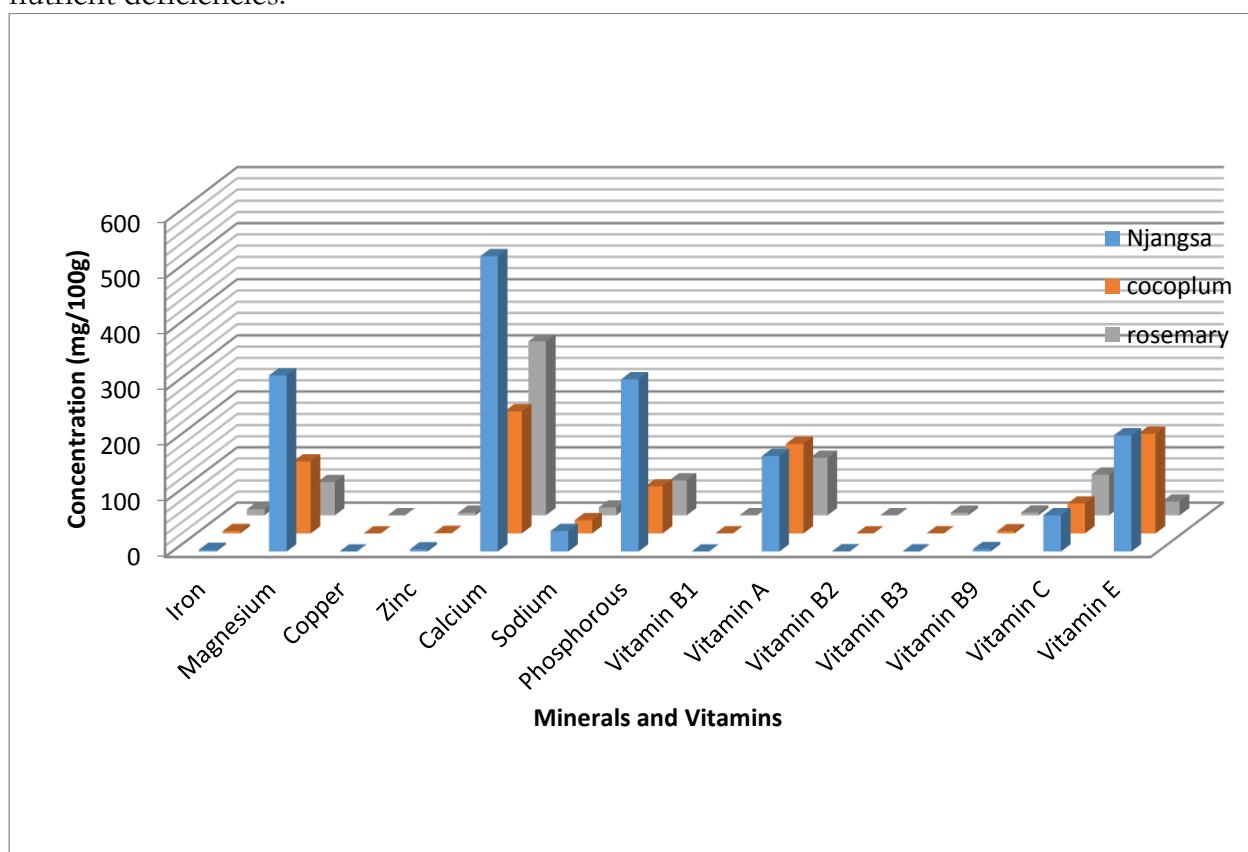


Fig 1: Mineral and Vitamin composition of Rosemary, Cocoplum (*gbafilo*) and *njangsa* spices.

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PHYSICOCHEMICAL PROPERTIES AND STORAGE STABILITY OF CRUDE PALM KERNEL OIL TREATED WITH THE EXTRACTS AND GRITS OF SELECTED NIGERIAN SPICES

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ABSTRACT - The objective of this study was to evaluate the storage stability of crude palm kernel treated with the grits and n-hexane extracts of *Aframomum danielli* (*A. danielli*), *Monodora myristica* (*M. myristica*) and *Monodora tenuifolia* (*M. tenuifolia*) and stored for 24 weeks at room temperature. Untreated palm kernel oil and α -tocopherol were used as controls. Storage stability indices were: free fatty acid and peroxide value. The order of free fatty acid development from lowest to highest was *A. danielli* extract < *A. danielli* grits < α -tocopherol (Vitamin E) < *M. myristica* extract < *M. tenuifolia* extract < *M. tenuifolia* grits < *M. myristica* grits < untreated sample. Again, the order of peroxide value development from lowest to highest was α -tocopherol (5.63 meq/kg) < *A. danielli* extract (6.04 meq/kg) < *M. myristica* extract (6.66 meq/kg) < *M. tenuifolia* extract (9.09 meq/kg) < *A. danielli* grits (9.33 meq/kg) < *M. tenuifolia* grits (10.10 meq/kg) < *M. myristica* grits (10.28 meq/kg) < untreated sample (13.54 meq/kg). The spice extracts had better storage stability than their grits. The study suggests that the n-hexane extracts and grits of *A. danielli*, *M. myristica* and *M. tenuifolia* can be used to extend the shelf life of palm kernel oil.

Keywords: Palm kernel oil, Antioxidants, *Monodora myristica*, *Aframomum danielli*, *Monodora tenuifolia*

Introduction

Palm kernel oil is obtained from the nut of the palm oil (*Elaeis guineensis*) tree. The palm oil tree grows in the tropical regions of Africa, Asia and South America. Palm kernel oil besides coconut oil is the only lauric oil of international trade importance. Lauric oils with their appreciable quantity of lauric acid are desirable as industrial materials in the production of chocolate, ice cream, cooking oil and soap. In these products, lauric acid imparts a desirable sharp melting point. Autoxidation reduces the nutritional, sensory, economic value and industrial applications of edible oils and initiates the formation of free radicals which cause degenerative and disease conditions in the human body. One of the methods to prolong the onset of autoxidation in edible lipids is by the addition of antioxidants. Antioxidants are food additives that extend the oxidation induction period of prone foods such as lipids thereby prolonging their shelf life. Natural antioxidants are gaining a rising popularity in recent times because they are potent just like synthetic antioxidants, are additional sources of nutrients, easily assimilated and are obtained from food-grade materials listed as GRAS (Generally Regarded as Safe). Spices are among one of such potent natural sources of antioxidants such as phenolics compounds. The *Monodora myristica* and *Monodora tenuifolia* plants belong to the same family and genus, Annonaceae and *Monodora*, while *Aframomum danielli*, common name, African cardamom, belongs to the genus, *Aframomum* and family, Zingiberaceae. All the spices grow in the tropical rainforest of Nigeria. Both *Monodora*

myristica and *Monodora tenuifolia* have the same English name, African nutmeg, but both are differentiated locally with *Monodora myristica* known locally as *eburu*, *arinwo* and *awerewa* by the Igbo, Hausa and Yoruba speaking tribes of Nigeria respectively. *Monodora tenuifolia* is locally identified as *Eburu obia*, *ehinawosin* and *Uyenghen* by the Igbo, Yoruba and Ijaw tribes of Nigeria. The three identified plants have been shown in studies to have high phenolics and antioxidant effectiveness (Akinwunmi and Oyedapo, 2014; Lawal *et al*, 2017). This study investigated the storage stability potentials of the grits and n-hexane extracts of the identified spices in crude palm kernel oil stored for 24 weeks at room temperature.

Materials and Methods

The spices were purchased at Eke Onunwa market in Owerri, Imo State, Nigeria while the palm kernel nuts were purchased in their prime from local suppliers in Atta, Ikeduru LGA, Imo State. All the reagents used in the study were of analytical grade, while the α -tocopherol (Vitamin E) (1000 IU) capsules were bought from a pharmacy shop. Authentication of the spices, *Monodora myristica*, *Aframomum danielli* and *Monodora tenuifolia* was done at the Taxonomy Unit of the Department of Botany, University of Nigeria, Nsukka. Cleaned palm kernels were slightly toasted in a preheated oven at 177°C for 10 minutes and milled in a hammer mill. The milled kernels were mixed with 2 liters of water and boiled at 100°C for 30 minutes. The floating oil was skimmed off, boiled at 100°C for 5 minutes to remove residual moisture, cooled and filtered. The palm kernel oil was packed in glass container and stored in the freezer at -20°C until it was used. One hundred and fifty grams (150g) of *M. myristica*, *A. danielli* and *M. tenuifolia* seeds were each sterilized with 75 mls of methanol and dried under the sun for 30 minutes to remove residual methanol. The spices were toasted in an oven at 177°C for 5 minutes and then dehulled to remove the seed coats. The *A. danielli* seeds did not require toasting due to their thin seed coats being fused to their embryo. The seeds were each milled using a hammer mill and then passed through a No 32-mesh sieve to yield their respective grits of 0.5mm particle size. The spice grits were appropriately packaged in covered plastic containers, labeled and stored at -20°C until used. The spices were each pulverized in a laboratory mill and placed in a soxhlet extractor unit and extracted using n-hexane at 40°C for 12 hours. The solvent containing the extract was filtered with Watman no.1 filter paper and centrifuged for 5 min at 5,000 rpm. The extraction solvent was evaporated using rotary evaporator at 40°C. The solvent-free extracts were packaged in sample vials, labeled and stored at -20°C until use. Two controls were used: one containing 0.02% tocopherol in palm kernel oil sample and another containing palm kernel oil without treatment. The extracts and grits of the three spices were each added into their respective palm kernel at a concentration of 0.02% each. Some physicochemical parameters of the samples were determined before storage (AOCS, 2004). During storage at $\pm 28^\circ\text{C}$, peroxide value and FFA of the palm kernel oil samples were measured (AOCS, 2004) at the fourth and eighth week and afterwards, every two weeks, until twenty four weeks. All determinations carried out were done in duplicates. Data was analyzed using SPSS 20 statistical software package. Analysis of variance (ANOVA) procedure was used to analyze the data statistically. Means were separated using the Fisher's Least Significant Difference.

Results and Discussions

From the result in Table 1, the moisture content of palm kernel oil was 0.20 %. Standard Organization of Nigeria recommends a moisture content of not more than 0.29% in

vegetable oils (Codex Alimentarius, 2013). High moisture content in vegetable oil increases hydrolysis and higher FFA values. Free fatty acid of the sample before storage was 2.10%. FFA indicates quality of raw material, processing and degree of purity (Mehmood *et al.*, 2012). The FFA of the freshly processed crude palm kernel oil was within the Codex quality standard of 3.3% for edible oils (Codex Alimentarius, 2013). The peroxide value of sample before storage was 0.40mEq/kg. Peroxide value assesses the degree of rancidity of oil by measuring the amount of peroxides formed. The result is below the recommended standard, 15mEq/kg (Codex Alimentarius, 2013). Saponification value of the PPKO before storage was 240.00 mgKOH/g. An inverse relationship of saponification value exists with the average molecular weight of the fatty acids. Oils with saponification values of 200mgKOH/g and above possess low molecular weight fatty acids. The relative density of palm kernel oil before storage was 0.916. It was within the standard range of 0.899-0.916 for palm kernel oil (Codex Alimentarius, 2013). Iodine value of palm kernel oil was 19.54 gI₂/100g. Iodine value is the percent by weight of molecular iodine absorbed by oil and is a standard for determining the amount of saturation in an oil sample. The higher the degree of unsaturation, the higher the iodine value. The iodine value of the palm kernel oil was within the Codex reference value range of 14.1-21gI₂/100g for palm kernel oil (Codex Alimentarius, 2013).

In Table 2, the peroxide values of the 24-weeks, room-temperature-stored untreated PKO and PKO samples treated with 0.02% (200ppm) spice n-hexane extracts and grits and α -tocopherol is shown. The Peroxide values of all the crude palm kernel oil samples were within the Codex recommended 15meq/kg standard (Codex Alimentarius, 2013) at the end of the storage period, with the lowest value (5.63 meq/kg) seen in α -tocopherol-treated PKO and the highest value (13.54 meq/kg) seen in the untreated PKO sample. The values are similar to those reported in literature (Mehmood *et al.*, 2012). Palm kernel oil is highly stable to oxidation during storage, due to its high saturation level. Again, the palm kernel oil samples treated with spice extracts had lower peroxide value than the palm kernel oil samples treated with spice grits. Spice grits could show better and promising antioxidant effectiveness at higher concentrations. In the results obtained in Nwagbo, *et al.*, (2020)^a and Nwagbo, *et al.* (2020)^b, *M. myristica*, and, *M. tenuifolia* extracts had better reducing effects on the peroxide value of groundnut oil and palm oil than *A. daniellii* and α -tocopherol. In another study, *A. daniellii* showed better antioxidant effectiveness at higher concentrations above 600 ppm than α -tocopherol and butylated hydroxyl toluene (Adegoke and Krishna, 1998). Natural antioxidants have been shown to act in synergy and could exert better effect in some medium compared to others. Also, according to the study by Nwagbo, *et al.*, (2020)^a and Nwagbo, *et al.* (2020)^b, both the extracts and grits of spices extended the shelf stability of palm oil and groundnut oil during storage. A quantity of 1000 ppm of *M. myristica* powder and 500 ppm *M. myristica* methanolic extract reduced the peroxide value of soya oil under accelerated oven storage for 24 days (Womani *et al.*, 2013). The rich phenolic constituents in *Monodora* species have been shown (Akinwunmi and Oyedapo, 2014). Phenolics are excellent scavengers of free radicals in edible oil.

Table 2 also shows FFA values of the room-temperature stored crude palm kernel oil samples. The FFA values ranged from 2.10 - 5.89%. The order of performance from lowest FFA value to highest was *A. daniellii* extract < *A. daniellii* grits < α -tocopherol (Vitamin E) < *M. monodora* extract < *M. tenuifolia* extract < *M. tenuifolia* grits < *M. monodora* grits < untreated sample. The overall values are higher than the FFA (0.810%) of refined soyabean oil samples treated with 0.02% sweet basil extract and stored for 5 months (Ajayi *et al.*, 2015).

Refining removes free fatty acids in edible oil. The FFA of the untreated palm kernel oil samples were the first to exceed the 3.3 % limit of Codex Alimentarius (2013) at the 4th week, while the sample treated with *M. tenuifolia* extract was the last to exceed the limit at the 10th week. *A. danielli* had better oxidation stability potentials than butylated hydroxyl toluene and α -tocopherol in peanut oil under accelerated storage at 65°C (Adegoke and Krishna, 1998). All the spice extracts extended the FFA induction period of the crude palm kernel oil better than the spice grits. Spice extracts represent the volatile and non-volatile compounds of spices and have higher concentration of active compounds per weight than whole spices. They also have advantages over whole spices by being free from physical impurities, extraneous matter and pathogens; being easy to use and versatile; they facilitate consistency in end use and are moisture free, thereby ensuring longer shelf life due to minimal oxidative degradation.

Conclusion

Monodora myristica, *Monodora tenuifolia* and *Aframomum danielli* treated PKO at a concentration of 0.02% (200 ppm) stored at room temperature, all showed storage oxidation stability comparable to α -tocopherol-treated samples and better than untreated samples. There was prolonged development of free fatty acid and peroxide value compared to untreated oil samples. Solvent extraction increased the antioxidant effect of the spices.

Table 1: Physicochemical properties of the fresh crude palm kernel oil before treatment and storage

Physicochemical Properties	Value
Moisture content (%)	0.20
Free fatty acid value (%)	2.10
Peroxide value (meq/kg)	0.40
Saponification number (mgKOH/g)	240
Relative density	0.916
Iodine value (g I ₂ /100g)	19.54

Table 2: Storage stability of Palm kernel oil samples treated with spice extracts, grits and α -tocopherol within 24 weeks storage.

Time (weeks)	Mean peroxide (mEq/kg) of PKO samples treated with spice extracts and grits and α -tocopherol within 24 weeks storage.								
	PKO	PKOVE	PKOMTg	PKOMTe	PKADg	PKADe	PKOMMg	PKOMMe	LSD
4	0.57 ^a ±0.07	0.52 ^a ±0.03	0.57 ^a ±0.10	0.52 ^a ±0.01	0.54 ^a ±0.05	0.51 ^a ±0.14	0.57 ^a ±0.04	0.54 ^a ±0.01	0.17
8	1.59 ^a ±0.04	0.72 ^a ±0.10	0.92 ^a ±0.02	0.82 ^a ±0.14	0.99 ^a ±0.11	0.64 ^a ±0.06	0.96 ^a ±0.04	0.68 ^a ±0.07	0.17
10	2.76 ^a ±0.08	0.94 ^a ±0.04	1.16 ^a ±0.04	1.14 ^a ±0.08	1.65 ^a ±0.07	0.87 ^a ±0.02	1.73 ^a ±0.05	1.36 ^a ±0.06	0.14
12	3.62 ^a ±0.01	1.19 ^a ±0.00	1.36 ^a ±0.08	1.29 ^a ±0.01	2.25 ^a ±0.04	2.04 ^{ab} ±0.21	2.32 ^a ±0.03	1.84 ^a ±0.03	0.23
14	4.11 ^a ±0.27	1.41 ^a ±0.08	1.87 ^a ±0.03	1.43 ^a ±0.04	2.55 ^a ±0.07	2.48 ^a ±0.17	2.95 ^a ±0.24	2.04 ^a ±0.05	0.34
16	4.76 ^a ±0.00	1.67 ^a ±0.10	2.09 ^a ±0.13	1.63 ^a ±0.08	2.97 ^a ±0.09	2.72 ^a ±0.03	3.37 ^a ±0.02	2.18 ^a ±0.05	0.18
18	6.29 ^a ±0.08	1.83 ^a ±0.04	3.68 ^a ±0.22	2.78 ^a ±0.11	3.54 ^a ±0.06	2.95 ^a ±0.07	4.09 ^a ±0.65	2.50 ^a ±0.14	0.59
20	7.80 ^a ±0.28	3.54 ^a ±0.24	4.87 ^a ±0.04	4.24 ^a ±1.17	4.22 ^a ±0.11	3.82 ^a ±0.03	5.10 ^a ±0.07	3.68 ^a ±0.01	2.35
22	10.72 ^a ±0.03	4.72 ^a ±0.06	8.69 ^a ±0.09	7.38 ^a ±0.01	7.82 ^a ±0.25	5.13 ^a ±0.04	8.92 ^a ±0.01	5.43 ^a ±0.04	0.23
24	13.54 ^a ±0.07	5.63 ^a ±0.06	10.10 ^a ±0.14	9.09 ^a ±0.14	9.33 ^a ±0.00	6.04 ^a ±0.06	10.28 ^a ±0.14	6.66 ^a ±0.08	0.23

Mean FFA (%) of PKO samples treated with spice extracts and grits and α -tocopherol within 24 weeks storage.									
	PKO	PKOVE	PKOMTg	PKOMTe	PKADg	PKADe	PKOMMg	PKOMMe	LSD
4	3.46 ^{ab} ±0.85	3.38 ^{ab} ±0.28	3.46 ^a ±0.28	3.34 ^{ab} ±0.85	3.25 ^{ab} ±0.70	3.20 ^a ±0.14	3.48 ^{ab} ±0.15	3.33 ^{ab} ±0.42	0.21
8	3.61 ^a ±0.57	3.57 ^a ±0.48	3.57 ^a ±0.85	3.42 ^a ±0.28	3.48 ^a ±0.57	3.50 ^a ±0.14	3.55 ^a ±0.70	3.50 ^a ±0.70	0.18
10	4.00 ^a ±0.70	3.87 ^a ±0.99	3.69 ^a ±0.14	3.57 ^a ±0.58	3.68 ^a ±0.11	3.65 ^a ±0.70	3.63 ^a ±0.42	3.61 ^a ±0.28	0.20
12	4.40 ^a ±0.14	4.00 ^a ±0.14	3.62 ^a ±0.28	3.62 ^a ±0.28	3.93 ^a ±0.42	3.84 ^{ab} ±0.85	3.83 ^{ab} ±0.42	3.80 ^{ab} ±0.14	0.22
14	4.68 ^a ±0.11	4.12 ^a ±0.11	3.76 ^a ±0.08	3.76 ^a ±0.08	4.05 ^a ±0.05	3.99 ^{ab} ±0.09	4.10 ^a ±0.07	4.04 ^a ±0.06	0.23
16	4.81 ^a ±0.03	4.26 ^a ±0.06	3.87 ^a ±0.10	3.87 ^a ±0.10	4.14 ^a ±0.08	4.11 ^a ±0.06	4.12 ^a ±0.07	4.15 ^a ±0.07	0.15
18	4.87 ^a ±0.04	4.30 ^a ±0.14	4.20 ^a ±0.07	4.20 ^a ±0.07	4.26 ^a ±0.08	4.23 ^a ±0.04	4.61 ^a ±0.01	4.18 ^a ±0.11	0.19
20	4.93 ^a ±0.04	4.42 ^{ab} ±0.02	4.34 ^{ab} ±0.14	4.34 ^{ab} ±0.14	4.48 ^{ab} ±0.02	4.27 ^a ±0.10	4.65 ^a ±0.21	4.56 ^{ab} ±0.06	0.24
22	5.64 ^a ±0.07	4.61 ^{ab} ±0.01	4.79 ^a ±0.13	4.79 ^a ±0.13	4.49 ^{ab} ±0.04	4.36 ^a ±0.14	5.20 ^a ±0.21	4.71 ^{ab} ±0.06	0.25
24	5.86 ^a ±0.08	4.85 ^a ±0.07	4.91 ^{ab} ±0.02	4.91 ^{ab} ±0.02	4.62 ^a ±0.03	4.61 ^a ±0.08	5.41 ^a ±0.28	4.89 ^{ab} ±0.13	0.30

PKO =Control 1(Palm Kernel oil); **PKOVE**=Control 2(Palm kernel oil and Vitamin E); **PKOMTg**= Palm kernel oil + *M. tenuifolia* (Efi) grits ; **PKOMTe** = Palm kernel oil + *M. tenuifolia* (Efi) extract; **PKOAdg**= Palm kernel oil + *A. danielli* (Urima) grits; **PKOAd**= Palm kernel oil + *A. danielli* (Urima) extract; **PKOMMg**= Palm kernel oil + *M. myristica* (Ehuru) grits; **PKOMMe** = Palm kernel oil + *M. myristica* (Ehuru) extract.

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EFFECT OF PRE-TREATMENT ON THE PHYTOCHEMICAL AND MINERAL COMPOSITION OF *VERNONIA AMYGDALINA*

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Abstract

This study investigated how to reduce phytochemical in *V. amygdalina* leaf during processing as a functional food ingredient. Fresh *V. amygdalina* leaf was processed using thermal oil-aqueous mixtures (soybean oil:aqueous and palm oil:aqueous) at 1:40 and 1:30 (v/v), respectively. Results indicated that alkaloids and polyphenols were retained at the rate of 81.34-98.50%, and mineral contents were retained at the rate of 33.33-96.91% using oil:aqueous mixture while aqueous recorded the rate of 33.47-41.46% for alkaloids and polyphenols and 28.37-71.69% for mineral. The use of soybean oil-aqueous at the ratio of 1:30 was established as the most suitable technique. The process is scalable and could be employed for domestic and industrial applications.

Keywords: *V. amygdalina* leaf, phytochemical, minerals, soybean oil, palm oil

1. Introduction

The increasing demand and exploitation of the functional food market have prompted researchers to evaluate the potentials of the phytochemical constituents and overall health benefits of many fruits and vegetable varieties using both in vitro and ex vivo models. Clinical and laboratory trials have shown a positive correlation between the consumption of fruits and vegetables and a steady reduction in the rate of heart diseases, cancers, other health complications, and even deaths (Delshadi et al., 2020). *Vernonia amygdalina*, commonly called “bitter leaf” is a soft-wooded shrub abundantly found in the tropics of Africa and Asia. The phytochemical and minerals composition of the leaves is responsible for the anti-diabetic, anti-microbial, anticancer, anti-inflammatory, antipyretic, anti-oxidative, and other health-promoting effects (Alara et al., 2019). *V. amygdalina* leaves often require the debittering process before consumption due to the characteristic bitter taste. Different processing methods are often employed in the debittering process including soaking, blanching, and washing with or without the application of salt and palm oil, and mechanical abrasion. The most locally applied washing method is the mechanical abrasion method that is often associated with the loss of nutrients and other water-soluble and heat-sensitive bioactive compounds in the leaves and subsequent modification of the nutrient composition. It is therefore very pertinent to evaluate these treatments given to “bitter leaf” during the debittering process and the effects on the nutritional and bioactive composition after the treatments. The objective of this study was therefore to investigate the effects of

hot oil-aqueous in the debittering process of bitter leaf on the phytochemicals and mineral content.

2. Materials and Methods

Freshly harvested bitter leaves were sorted, de-stalked, and cleaned in water to remove dirt and other extraneous materials. The leaves were allowed to drain through a plastic sieve for 1 h after which it was manually diced into 5 mm with the help of a stainless steel table knife. The diced leaves were sub-divided into six groups, each group weighing 1 kg. The six groups were then debittered individually by boiling the bitter leaf in oil-water treatments for 10 min each as follows: Sample one was boiled in 10 L of soybean oil-water (1:40, v/v); the second sample was boiled in 10 L of soybean oil-water (1:30, v/v); the third portion was boiled in 10 L palm oil-water (1:40, v/v); the fourth sample was boiled in 10 L palm oil-water (1:30, v/v); the fifth sample was boiled only with 10 L distilled water without the application of oil, while the sixth sample was untreated. All the samples were then drained, cooled, and dried at 50 °C for 36 h using a hot air conventional oven (Model P. P. 22 US. Genlab, England). The dried samples were milled using an attrition mill and packaged in polypropylene plastic containers, labeled and cold-stored at 4 °C in a refrigerator for analyses. The method described by Raji et al. (2019) was used to extract the alkaloids, saponins, and tannins with slight modifications. Using the Atomic Absorption Spectrophotometer (PG 990, Shanghai Drawell Scientific Instrument Co.Ltd, China), the mineral content of the *V. amygdalina* samples was determined as described by Ubwa (2015).

Statistical analysis

A completely randomized experimentation technique was utilized to avoid systematic errors. Evaluation of significant difference among means at 5% significant level by Duncan test was performed using the SPSS version 17.

3. Results and Discussion

Table 1 shows the phytochemical content of *Vernonia amygdalina* leaf as altered by a hot oil-aqueous mixture. The boiling treatment significantly reduced the phytochemical content of *V. amygdalina*. The fresh leaf of *V. amygdalina* contained phytate (1.85 mg/100g), oxalate (2.09 mg/100g), alkaloids (3.16 %), polyphenols (7.35 mg/100g), saponins (3.19 %), and tannin (3.58 mg/100g). Whereas phytate levels in de-bittered *V. amygdalina* ranged from 0.09 mg/100g to 1.07 mg/100g, oxalate levels ranged from 0.12 mg/100g to 2.04 mg/100g, alkaloids (1.31 %-2.98 %), polyphenols (2.46 mg/100g-7.224 mg/100g), saponins (0.52%-3.101%), and tannin 1.05-3.38 mg/100g. Table 2 showed the mineral contents (calcium, magnesium, potassium, sodium, manganese, iron, zinc, and copper) of *V. amygdalina* treated with hot soybean oil-water at ratios of 1:40 and 1:30 ranged from 1.28 mg/100g to 85.20 mg/100g and 1.62 mg/100g to 90.64 mg/100g, respectively. The highest retention rate of 96.31% for hot soybean oil-water at 1:40 was recorded against iron and the least (45.39%) for copper. The results indicated the greatest loss of minerals in the sample de-bittered with hot water. The current study discovered that blanching *V. amygdalina* leaves lowered mineral levels by 1.8–71.63% (Table 2). This is consistent with the results of Agomoo, (2016), who found a significant reduction in K, Ca, Mg, Na, Fe, and Zn content in the blanched *V. amygdalina*. These phytochemicals have a variety of pharmacological and biochemical activities and have been shown to be helpful to human health as well as have antioxidant activity (Ali et al., 2019). The food business employs a variety of standard thermal processing

procedures, and the relevance of phytochemical substances makes it worthwhile to analyze these processes in terms of their impacts on these phytochemicals. Meanwhile, some beneficial components like phytochemicals, and minerals are compromised during the de-bittering process of *V. amygdalina*, so there is a need to limit their losses. As a result, the boiling method was created for simple de-bettering. Although the boiling procedure requires less labor and time, it also results in the loss of beneficial components. The use of soybean and palm oils in the thermal de-bittering of *V. amygdalina* resulted in lower phytochemical losses when compared to the sample boiled without oil and that de-bittered with a soybean oil: aqueous mixture, which had higher amounts of phytochemicals and mineral content.

Table 1. Phytochemical content of *Vernonia amygdalina* leaf as influenced by hot oil-water mixture

Parameters	1:40 boiled soybean oil-water mixture	1:30 boiled soybean oil-water mixture	1:40 boiled palm oil- water mixture	1:30 boiled palm oil- water mixture	Boiled with water only	Un- debittered (raw)	1:40 boiled soybean oil-water mixture	1:30 boiled soybean oil-water mixture	% Retention		Boiled with water only
									1:40 boiled palm oil- water mixture	1:30 boiled palm oil- water mixture	
Phytate (mg/100g)	1.69±0.00 ^b	1.70±0.01 ^b	1.62±0.02 ^a	1.65±0.02 ^a	0.09±0.00 ^a	1.85±0.01 ^a	91.35	91.89	87.57	89.19	4.86
Oxalate (mg/100g)	2.00±0.01 ^b	2.04±0.03 ^b	1.70±0.01 ^a	1.86±0.01 ^a	0.12±0.01 ^a	2.09±0.01 ^a	95.69	97.61	81.34	89.00	5.74
Alkaloids (%)	2.94±0.01 ^a	2.98±0.02 ^a	3.04±0.01 ^b	3.10±0.04 ^b	1.31±0.02 ^a	3.16±0.05 ^a	93.04	94.30	96.20	98.10	41.46
Polyphenols (mg/100g)	7.16±0.04	7.24±0.09	6.81±0.05	6.95±0.11	2.46±0.03	7.35±0.10	97.41	98.50	92.65	94.56	33.47
Saponins (%)	2.96±0.07 ^b	3.01±0.10 ^b	2.10±0.03 ^a	2.15±0.08 ^a	0.52±0.00 ^a	3.19±0.02 ^a	92.79	94.36	65.83	67.40	16.30
Tannin (mg/100g)	2.97±0.01 ^b	3.10±0.04 ^b	2.90±0.02 ^a	2.92±0.01 ^a	1.05±0.02 ^a	3.58±0.05 ^a	82.96	86.59	81.01	81.56	29.33

Values are means ± standard deviation (n = 4).

Mean values in the same row with different letters are significantly different at a 5% significant level.

Table 2. Mineral and vitamin contents of hot oil-water de-bittered *Vernonia amygdalina* leaf

Parameters	1:40 boiled soybean oil- water mixture	1:30 boiled soybean oil- water mixture	1:40 boiled palm oil- water mixture	1:30 boiled palm oil- water mixture	Boiled with water only	Un- debittered (raw)	1:40 boiled soybean oil-water mixture	1:30 boiled soybean oil-water mixture	1:40 boiled palm oil- water mixture	1:30 boiled palm oil- water mixture	Boiled with water only
% Retention											
<i>Minerals (mg/100g)</i>											
Calcium	85.20±1.08 ^c	90.64±0.95 ^b	70.16±0.31 ^a	78.29±1.35 ^a	65.28±0.16 ^c	108.17±1.26 ^a	78.76	83.79	64.86	72.38	60.35
Magnesium	21.09±1.11 ^a	21.95±0.90 ^a	17.98±0.11 ^b	18.01±0.09 ^b	13.28±0.31 ^a	23.38±1.85 ^a	90.21	93.88	76.90	77.03	56.80
Potassium	30.00±0.91 ^a	30.05±0.81 ^a	26.08±0.41 ^a	28.11±0.15 ^b	22.59±0.28 ^a	31.51±0.36 ^a	95.21	95.37	82.77	89.21	71.69
Sodium	9.35±0.73 ^b	12.48±0.84 ^a	6.95±0.08 ^a	8.24±0.06 ^c	5.34±0.04 ^a	14.08±0.71 ^a	66.41	88.64	49.36	58.52	37.93
Manganese	3.11±0.06 ^a	3.82±0.11 ^a	1.97±0.04 ^a	2.19±0.02 ^b	1.85±0.01 ^a	3.89±0.06 ^a	79.95	98.20	50.64	56.30	47.56
Iron	27.12±0.80 ^a	27.29±0.90 ^a	24.03±0.41 ^b	24.17±0.52 ^b	19.65±0.18 ^a	28.16±0.69 ^a	96.31	96.91	85.33	85.83	69.78
Zinc	10.09±0.14 ^b	10.21±0.56 ^b	8.04±0.16 ^a	9.81±0.18 ^a	6.02±0.09 ^a	12.14±0.65 ^a	83.11	84.10	66.23	80.81	49.59
Copper	1.28±0.01 ^a	1.62±0.07 ^b	0.94±0.03 ^a	0.95±0.01 ^a	0.80±0.01 ^a	2.82±0.02 ^a	45.39	57.45	33.33	33.69	28.37

Values are means ± standard deviation (n = 4).

Mean values in the same row with different letters are significantly different at a 5% significant level.

4.0 Conclusion

The *V. amygdalina* leaf is rich in phytochemical and minerals. The debittering of the leaf, which is a key processing operation in its use as a functional food ingredient results in huge losses of phytochemical. This study showed that the use of hot soybean oil-aqueous mixture could reduce the phytochemical and minerals losses. The use of soybean oil-aqueous at the ratio of 1:30 was established as the most suitable technique. The process is scalable and could be used in both domestic and industrial applications

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FABRICATION AND PERFORMANCE EVALUATION OF A SLICING MACHINE USING IRISH POTATO AS TEST SAMPLES

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ABSTRACT

Fabrication of slicing machine was designed and its performance was evaluated using Irish potatoes as test materials. It was fabricated with the objective of solving problems associated with food processing and preservation of root and tubers. Fabricating a slicing for effective food processing was done using locally sourced materials such as stainless steel and angle iron for the main frame. The design was powered by electricity; with an electric motor of constant speed 1725 rpm. Irish potatoes of three different batch loads (1, 1.5 and 2 kg) were used at residence times of 100, 160, and 184s till the end of the operation. The results obtained were used to calculate the slicing efficiency (1kg:70.59%; 1.5kg:86.75%; 2kg:90.45%) and capacity at batch load of (1kg:0.876; 1.5kg:0.753; 2kg:0.643). The study concluded that the slicing machine was established to be efficient in slicing Irish potatoes of large capacities with reduced product losses and processing time hence confirming its effectiveness.

Keywords: Peeling, Fabrication, Slicing machine, Drudge.

INTRODUCTION

Potato (*Solanum tuberosum*) is a major food crop grown in more than 100 countries in the world, herbaceous annual crop rich in starch. Is the world's fourth most important food crop after wheat, rice and maize (Bradshaw, 2010). They are popularly known as "The king of vegetables". Irish potato is as high protein content, dry matter and edible energy which makes it nutritionally superior vegetable as well as staple food.

Srivastava, (2002) stated that its high post-harvest agricultural operations losses may occur due to poor handling and storage which can be eliminated by improving on it post-harvest. There are thousands of different potato varieties and are often differentiated by their waxiness (FAO 2008).

Irish potatoes are typically in the white potato group characterized by light tan to cream colored skin, and a white flesh that has a waxy texture due to moderate to low amounts of starch.

The starchy tubers quickly became one of the world's most important and nutritious foods, behind only corn, wheat, and rice. All part of the plants is toxic if eaten, except for the properly-harvested and stored tubers.

The processing of food items has become an important aspect in human daily consumption of food. It is a process by which a raw food is transformed to edible food for consumption by humans or by the food processing industry.

The processing involves applications of engineering technology with the aid of food science or manually, to change the appearance, taste, shape, or color of selected agricultural food produced in order to satisfy human daily needs of food (Oke, 2013). Slicing is a form of size reduction and the general term "size reduction" includes slicing, cutting, crushing, chopping, grinding and milling. The reduction in size is brought about by mechanical means without change in chemical properties of the material and uniformity in size and shape of individual units of the end product. Such processes as cutting of fruits or vegetables for canning, shredding sweet potatoes for drying, slicing onion for salad, chopping corn fodder, grinding grain for livestock feed and milling flour are size reduction operations. Reducing the size of food raw materials is an important operation to achieve a definite size range (Emadi *et al.*, 2008).

Slicing is vital during potato processing. Slicing, another stage of tuber processing is mainly done with a sharp blade to cut the potato into desired thickness followed by drying to impart better shelf life and increase the surface area of the tubers. This depends on the physical properties of the potato tuber like shape, size, length and moisture content. Tubers must be sliced into smaller pieces to facilitate heat transfer and removal of moisture from the pieces (Leo and Balogun, 2009). The sharpness of knife used for potato slicing could reduce the potato tissue damage (Akomas and Otti, 2000). The slices produced by local methods are not uniform and this may result in non-uniform dried slices.

Tuber damage will be minimal and potato slices will be more uniform. This would result in improved quality of potato which makes it safer for consumption without imposing any hazards.

MATERIALS AND METHODS

Sample collection and preparation

Potato was selected for this study, so it is essential to know and determine the database of physical and engineering properties of this crop because it plays an important role in the design and fabrication of potatoeslicing machine. These materials were procured locally from Alabara market, Lagos state and potatoes were gotten from Sayedero market in Ilaro Ogun State.

The slicing was designed based on the procedures described by (Mohammed *et al.*, 2017) on design and development of an industrial food material dryer and the procedures described by (Kumara *et al.*, 2015) on development fabrication and performance evaluation of Irish potato slicing machine.

The tuber was cleaned manually to remove dust, dirt and stone before determine the mean size of the tuber. White Irish potato is the varieties of potatoesthat were selected randomly according to their size and it was divided into ten samples.

Slicing Efficiency

This is defined as the ratio of weight of uniform sliced Irish potatoes to the weight of the Irish potatoes fed (Hoque and Saha, 2017):

$$\eta_s = \frac{Q_n}{Q_f} \times 100 \quad 1$$

where: η_s is the slicing efficiency

Q_n is the weight of uniformly sliced Irish potatoes

Q_f is the weight of the Irish potatoes fed

Slicing Capacity

This is the quantity of the Irish potato sliced in a given time (Hoque and Saha, 2017) and was given as:

$$S_c = \frac{Q_t}{T} \quad 2$$

where: S_c is the slicing capacity

Q_t is the quantity of Irish potatoes sliced

T is the slicing time

Percent Non-Uniformity

This is defined as the ratio of weight of non-uniform sliced Irish potato to the total fed into the machine and was calculated using (Hoque and Saha, 2017) equation:

$$\text{Percent non - uniformity} = \frac{Q_n}{Q_f} \quad 3$$

where: Q_n is the weight of non-uniform sliced Irish potato

Q_f is the total fed into the machine.

RESULTS AND DISCUSSION

Performance Evaluation of the Slicing Machine

Effect of Time on Slicing Capacity

At the end of the peeling process, the samples were transferred to the slicer. On slicing, the average thickness of the slices was 1.5 mm. As shown from Table 1, the capacity of the power-operated potato slicing machine was mainly affected by the time and the batch load of the tubers on slicing machine. For the 1 kg batch load, the capacity was 0.876 kg/s at 100 s. An increase in batch load to 1.5 kg decreased the capacity to 0.753 kg/s at an increased time of 160 s. For 2 kg, the capacity decreased to 0.643 kg/s at an increased time of 184 s. The highest capacity obtained was for 1 kg at 100 s batch load, followed by 1.5 kg at 160 s and finally 2 kg at 184 s. This showed that the quantity of potato fed into the machine at 1 kg was lower compared to that of 1.5 kg and the quantity increased at 1.5 kg and 2 kg; causing an increase in the time required by the machine to slice and reducing its capacity. However, the weights of chips gotten at 1 kg were lower than that of 1.5 kg with the highest weight of chips obtained at 2 kg when physically analyzed. These results showed that an increase in the batch load also increased the slicing time but reduced the slicing capacity. Also, it was shown that the lower the time, the higher the slicing capacity and the higher the batch load, the higher the time. These results were similar to those reported by Hoque and Saha (2017) on a potato and sweet potato slicer

Table 1: Effect of Time on Slicing Capacity

Speed(rpm)	Batch Load (kg)	Residence Time(s)	Slicing Capacity (kg/s)
1725	1	100	0.876
	1.5	160	0.753
	2	184	0.643

Effect of Batch Load on Slicing Efficiency

The results of the data generated from the slicing operations showed that average slicing efficiency and non-uniform sliced potato from the batches were 90.45% and 9.55% respectively. This showed the effectiveness of the slicer for better quality slices. The higher percentage of non-uniform slicing efficiency was as a result of smaller diameter Irish potatoes. The percentage of non-uniform slices could be reduced by using uniform round shaped Irish potatoes.

As shown from Table 2, the efficiency of power-operated potato slicing machine was mainly affected by the batch load of the tuber on slicing machine.

Table 2: Effect of Batch Load on Slicing Efficiency

Speed(rpm)	Batch Load (kg)	Initial Weight Fed (kg)	Weight of Uniform Slices (kg)	Slicing Efficiency (%)
1725	1	0.870	0.619	70.59
	1.5	1.280	1.123	86.75
	2	1.704	1.538	90.45

The slicing efficiency ranged from 70.59% to 90.45%. For 1 kg batch load, the slicing efficiency was 70.59%, 86.75% for 1.5 kg and 90.45% for 2 kg batch. This result showed that an increase in the batch load resulted to an increase in the slicing efficiency which was similar to the results reported by Kamaldeen and Awagu (2013) on a potato and sweet potato slicer where it was shown that the higher the batch load, the higher the slicing efficiency.

Conclusion

The slicing machine was designed, fabricated and its performance was evaluated to test the slicing efficiency using sweet potatoes. The machine was simple to fabricate at a relatively low cost with the ability to produce thin uniform slices. It was safe to operate, minimized direct human contact, saved time and increased product output.

To overcome post-harvest loss of fresh tubers due to improper handling and storage, Irish potatoes can be processed by slicing, using mechanical slicing machine. Therefore, the fabricated slicing machine was able to operate efficiently by reducing products losses and ensuring overall safety, uniform and quality of processed products.

Recommendation

On the completion of testing the slicing machine according to the selected test parameters, it is recommended that the designed slicing machine can be used conveniently in the laboratory to slice different small root tubers, thus reducing labor cost and time and increasing the quality of products.

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