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Sensory Properties of Bread Fortified with Soya Protein Isolate and Fonio Blends

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Abstract

In this study, the sensory properties of bread produced from composite flours ranging from 31.75 ≤ wheat ≤ 49.21, 2.38 ≤ soy protein isolate (SPI) ≤ 15.87, and 1.32 ≤ fonio flour ≤ 7.94 at 187.5oC for 30min at constant temperature and time were determined. A modified straight-dough procedure was used to produce the bread. The sensory properties of the composite bread determined were color, taste, aroma, texture, and overall acceptability. Analysis of variance indicated that the linear, quadratic, and interactive effects of A (wheat flour), B (soy protein isolate), and C (fonio flour) significantly ($p \leq 0.05$) affected all the composite bread properties evaluated. The bread with optimal quality indexes and an overall desirability index of 0.568 was obtained from 39.42% wheat, 6.28% SPI, and 13.76% Fonio. The sensory properties of this optimal bread were: appearance (4.07), taste (4.40), aroma (3.89), texture (3.89), and overall acceptability (3.56). It was concluded that there was no significant difference observed between the whole wheat and the composite bread sample in the sensory attributes of taste and color, while significant differences were observed in texture, aroma, and overall preference, respectively.

Keywords: Sensory properties; Composite bread; Fonio; Wheat flour; Soya protein isolate

Introduction

A common cereal-based food consumed in Nigeria is bread, which is made from wheat flour. The main ingredient in almost all breads is wheat flour because, when combined with water, it creates a special visco-elastic dough [1]. However, non-wheat flours can be used to make high-quality bread. The high cost of wheat is a concern for the bakery business, necessitating the use of other cereal flours, such as fonio, soybean, and other cereals, which are less expensive and more environmentally friendly [2]. The complex process of making bread primarily consists of various baking-related procedures that are combined to produce a single process. Dough mixing converts the mixture of flour and water into homogenous visco-elastic dough for subsequent dough development and air inclusion [3]. These processes include fermentation and baking, which cause water evaporation, volume expansion, starch gelatinization, protein denaturation, and crust formation. Nowadays, it's very common to consume baked foods like breads, biscuits, doughnuts, and cakes made from wheat flour, but its low protein content, which makes it the most important ingredient used to make various types of baked goods, raises serious questions about its use [4]. Since wheat does not grow well in Nigerian soils and climates, a substantial sum of money is spent on importing it each year [5]. As a result, there is an urgent need to find other sources of flour in order to decrease the importation of wheat. Organization for Food and Agriculture [6]. According to the most recent estimates, there are more than a billion malnourished individuals in the world. According to the World Food Program (WFP) [7], there are over 70 million undernourished children in Africa. According to Mayer et al. [8], starchy foods such as maize, wheat, rice, sorghum, millet, and cassava are the mainstays of the diets of vulnerable populations in this region. Meat and dairy products are either scarce or unaffordable.

Bread fortification Technology in Nigeria has been long overdue and needed to change the baking landscape in Nigeria and other developing countries. This is due to the peculiar wheat non-availability and its consequent effect on economies. Several research studies have been exhaustive in this regard, but each research finding is always peculiar to a particular raw material with a different approach, condition of baking, and raw materials/mix ratio. However, the identification of the best raw material optimization among all the variables to achieve the desired baking quality is an uphill task [9]. Okoye and Okaka [10] reported that legumes can be used to complement other cereals when blended in optimum proportion.

Lysine makes up a significant portion of the protein in soybeans (Glycine max), a legume with an exceptionally high protein content that ranges between 38% and 42% [11]. Soybeans are regarded as a superior source of high-quality plant protein because they contain all the essential amino acids needed for healthy body development and maintenance. According to Dandago and Igwe [12], a suitable and practical processing technique should be used to make soybeans safe, pleasant, digestible, nutritious, and to improve the quality of goods.

Despite being one of the oldest native grains from West Africa, fonio has long been ignored by scientific research and development initiatives. Its species are members of the Poaceae family, subfamily of Panicoideae, tribe of Paniceae, and genus Digitariahaller. In Nigeria, Benin, Burkina Faso, Guinea, Mali, and Togo, it is known as acha, ipouaga, feningue, findi, kansambahon, and ova, respectively.

Fonio, according to Coulibaly et al. [13], is more than just an intriguing substitute for grains that are more often used. The grain contains a variety of phytochemicals, including phytic acid, which may help lower cholesterol, and phytate, which has been linked to a lower risk of cancer. Fonio is gluten-free, making it a fantastic choice for those with celiac disease who are frequently aggravated by the gluten content of wheat and other more widely consumed cereal grains. According to Gelinas et al., it is also beneficial for those who have atherosclerosis and diabetic heart disease.

Numerous studies on composite bread have been conducted, with a focus on its physicochemical and nutritional qualities. This study will focus on how varying levels of fortification affect the bread's sensory qualities.

Materials and Methods

Materials

The following materials were used in the study: wheat flour (Dangote brand), soybean, fonio seeds, sugar (Golden penny), and margarine (Simas brand, Assar-Cozinhar Industries Indonesia), baking improver (Batta Baker brand), dry yeast (SKT-Royal instant yeast), salt (Dangote brand), which was procured at Kure Market Minna, and water.

Methods

Preparation of Soybean Flour

The method of Otegbayo et al. [14], with a slight modification, was used. Soybean seeds were cleaned to remove dirt and foreign materials. The seeds were then weighed and soaked in hot water for 1 hour to soften the hulls, dehulled, and dried in a cabinet dryer at 60°C for 72 hrs. The dried soybean seeds were cooled, milled, and sieved with a 65µm mesh. The flour was stored in polyethylene films until needed.

Preparation of Fonio Seed Flour

Fonio seeds were cleaned to remove dirt and foreign materials. The seeds were then weighed, milled, and sieved with a 250 µm mesh to get the fonio flour. The flour samples were stored in polyethylene films until needed, as reported by Coda et al. [15].

Preparation of Soy Protein Isolate (SPI)

Soy protein isolate was prepared following an isoelectric precipitation method as described by Petruccelli and Anon [16]. The prepared soy flour was suspended in 10-fold deionized water with mild stirring, and the pH of the suspension was adjusted to 8.5 with 2 mol/L NaOH. After 1 hour of extraction, the dispersion was centrifuged at 14,000 g for 30 min. The supernatant was acidified with 2 mol/L HCl to pH 4.5 and centrifuged under the same conditions. The precipitate was redispersed in water, adjusted to pH 7.5 with 1 mol/L NaOH, dialyzed against deionized water for 24 hours, and then lyophilized. The moisture content of the final product was less than 5%, while the protein content was 90%, as determined by the Bradford assay with bovine serum albumin as the standard protein. The laboratory work was carried out at STEP B of the Federal University of Technology, Minna, Niger State.

Formulation of the Bread Wheat, Soy Protein Isolate, and Fonio Flour Composite Bread

The major ingredients (wheat, SPI, and fonio) give 52.91% of the formulation, while the other ingredients include water (26.46), yeast (1.06), salt (1.06), granulated sugar (3.18), margarine (2.12), and baking improver (13.23).

Composite Bread Baking

The modified straight dough method of Onuegbu et al. [17] was used to produce the composite bread. Wheat flour, Fonio flour, SPI, fat, baking improver, water, dry yeast, sugar, and salt were all mixed for 15 minutes in various proportions. The dough was combined, then molded into pans with grease after being kneaded. The dough was proofed for 30 minutes at 50 degrees Celsius in a proofing cabinet, and then it was baked for another 30 minutes at 187.5 degrees Celsius in a preheated electric oven, which was carried out at the Agricultural and Bioresources Engineering laboratory at the Federal University of Technology, Minna. Depanning, cooling, packing in polyethylene bags, and storing the bread samples at room temperature until further analysis were performed. Dough proofing and composite bread samples are shown in Figure 1.

Figure 1: *Composite Bread Samples.*

Determination of Sensory Properties

The sensory properties were determined by human interpretation as perceived by human senses of taste, texture, and appearance [18]. The sensory evaluations were carried out immediately after the production and cooling of the composite bread. The sensory evaluation was designed based on the 5-point hedonic scale, which enables them to express exactly the range of their choice between acceptance and rejection. They are as follows: very good, good, average, fair, and bad. A total of 10 respondents were used to evaluate the sensory attributes of the composite bread.

Experimental Design

Optimization of the process parameters was carried out using process mixture design. The experimental plan for the mixture consists of three independent parameters: wheat flour, fonio flour and soy protein isolate. The experimental plan for the process consists of two independent parameters: baking temperature and baking time. The dependent variables are texture, taste, aroma, and color variables in terms of L*, a*, and b* of bread. The independent variables varied using a 23-factorial design matrix. The levels of the factorial design are illustrated in Table 1. The experimental layout for the experimental runs is as presented in Table 2.

Table 1: *Formulation Constraints.*

Variables	Unit	Levels	
		Low	High
Wheat	%	31.746	49.207
Fonio	%	1.322	7.936
SPI	%	2.381	15.873

Table 2: *Design Matrix for Fortified Composite Bread Production.*

Run	Wheat flour (%)	Fonio flour (%)	Soy protein isolate (%)	Baking temperature (°C)	Baking time (min)
1	36.69	3.38	12.83	187.5	30
2	38.47	6.95	7.49	187.5	30
3	35.72	1.32	15.87	187.5	30
4	49.21	1.32	2.38	187.5	30
5	44.91	2.91	5.09	187.5	30
6	31.75	7.94	13.22	187.5	30
7	49.21	1.32	2.38	187.5	30
8	45.11	5.42	2.38	187.5	30
9	42.38	1.32	9.2	187.5	30
10	34.92	7.94	10.05	187.5	30
11	31.75	5.29	15.87	187.5	30
12	40.22	7.94	4.75	187.5	30
13	39.31	1.32	12.28	187.5	30
14	31.75	5.29	15.87	187.5	30
15	41.67	4.48	6.76	187.5	30
16	42.6	7.94	2.38	187.5	30
Control	52.91			187.5	30

Statistical Analysis

The statistical analysis was performed using Design Expert Software (version 11), which provides test matrices for screening all the factors in determining the best lines or points of fit for the purpose of final optimization using a Response Surface Methodology (RSM).

Results and Discussion

Results

The results of the study are shown in Tables 3, 4, and 5, respectively.

Sensory Evaluation

The result (means) of the sensory evaluation of the bread samples (composite and control) is presented in Table 3.

Table 3: *Means of Sensory Score Based on the 5-Point Hedonic Scale.*

Run	Colour	Taste	Aroma	Texture	Acceptability
1	3.8	3.0	3.2	3.1	3.2
2	3.8	2.1	3.5	3.0	2.5
3	3.9	3.6	3.7	3.3	3.4
4	3.8	2.9	3.7	3.5	3.4
5	3.9	3.5	3.3	3.4	3.4
6	4.1	3.8	3.7	3.1	3.7
7	4.0	3.4	3.6	3.8	3.3
8	3.7	3.8	3.7	3.9	3.6
9	4.3	3.9	3.9	3.5	3.8
10	4.1	4.0	3.7	4.1	3.9
11	4.3	4.0	3.6	3.6	4.0
12	4.6	4.0	4.0	4.2	4.1
13	3.7	3.7	3.6	3.8	3.6
14	3.7	3.9	3.8	3.4	3.8
15	4.4	4.1	3.7	3.9	4.0
16	4.8	4.3	3.8	3.8	4.1
Control	4.9	5.0	4.5	4.5	4.8

Optimum Condition of Composite Bread

The sensory properties of the bread, with an overall desirability of 0.57, are summarized in Table 4.

Table 4: *Optimum Condition of Composite Bread Samples Produced.*

Parameters	Unit	Optimal condition
Colour	%	4.07
Taste	%	4.4
Aroma	%	3.89
Texture	%	3.89
Acceptability	%	3.56
Desirability	%	0.57

Discussion

Sensory Evaluation

The sensory evaluation properties of the composite bread samples and control are presented in Table 3. The evaluation was done based on a five-point hedonic scale. The color, taste, aroma, texture, and overall acceptability of the composite bread samples were compared with the control bread (100% wheat). There was a significant statistical difference in the rating within each attribute. This implies that the differences observed were actually due to the substitution levels of wheat, soy protein isolate, and fonio flour, as they affected the preferences of the panelists.

The ratings for taste of the bread by the participants showed that 100% wheat flour bread, 41.67% and 42.59% flour substituted bread, respectively, were the most preferred products, as shown in Table 3. In many parts of the world, consumers are familiar with the taste of the products they regularly consume [8]. Presumably, bread with a higher ratio of wheat (90%) and a lower ratio of soy protein isolate (5%) and fonio flour (5%) scored the highest, which is similar to those reported in different past studies [19,20].

However, changing the proportion of soy protein isolate and fonio flour from 5% to 10% each shows a significant difference in the taste of the bread that reflects the bland taste nature of the soy protein isolate. Similar findings were reported by Dewettinck et al. [21], Ibebuchi and Uzoegbu [22], Dhingra and Jood [23], and Otegbayo et al. [14].

Aroma is the main criteria that determines whether a product is liked or disliked [24]. The sensory ratings showed that the most preferred products were the 100% wheat flour bread, 6.75%, 9.20%, and 15.87% soy protein isolate and fonio flour substituted breads, respectively, as shown in Table 4.2. The sensations of taste and aroma are functions of flavor, which is a complex of sensations [25]. Food flavor, according to Azumugha and Uwalaka [26], arises from a subtle interaction of taste and aroma, which imparts a pleasing or displeasing sensory experience to a consumer. It is the flavor of a food that ultimately determines its acceptance or rejection, even though its appearance evokes an initial response.

In terms of bread color, the 100% wheat flour bread and the 2.38 and 7.94% each soy protein isolate and fonio flour substituted bread were most preferred. The preference for the bread color reduced considerably as the quantity of soy protein isolate and fonio flour increased; the bread became darker brown in color. The result in Table 3 shows that higher ratings were given to the bread products with lower quantities of soy protein isolate and fonio substitution. The brownish bread appearance could be attributed to the high fiber content in the bread [27]. Color is a very important parameter in judging properly baked bread that not only reflects the suitable raw material used for the preparation but also provides information about the formulation and quality of the product [24].

The texture (softness and chewiness) of the composite bread decreased as the composite flour substitution increased. This characteristic can be attributed to the high fiber content of the bread. The observation indicates that average supplementation of soy protein isolate (10.05%) and high supplementation of fonio flour (7.94%) showed average scores on texture (4.1), as shown in Table 3.

The overall rating followed the trend for all other sensory attributes; 100% wheat flour breads, 5% each, 2% to 13%, and 7% to 8% soy protein isolate and fonio flour substituted breads were the most preferred products overall, respectively.

The results of this study are consistent with previous comparable studies in which wheat flour was largely replaced with flour from other sources, particularly tubers [28], in order to increase its applications. It was found that preference declined above 15% substitution levels for soy protein isolate and fonio flour [29].

Conclusion

In conclusion, mixture design was used for the production of composite bread, and response surface methodology (RSM) was effective for estimating the effect of three independent variables: wheat (A), soybean protein isolate (B), and fonio (C) at constant temperature and time of 187.5oC and 30min, respectively, on the sensory properties of composite bread. ANOVA indicated that the linear, quadratic, and interactive effects of A, B, and C significantly ($p < 0.05$) affected all the composite bread properties evaluated. The bread with optimal quality indexes and an overall desirability index of 0.568 was obtained from 39.42% wheat, 6.28% SPI, and 13.76% Fonio. The properties of this optimal bread were: color 4.07, taste 4.40, aroma 3.89, texture 3.89, and acceptability 3.56. The sensory analysis showed that there was no significant difference observed between the whole wheat and the composite bread sample in the sensory attributes of taste and color, while a significant difference was observed in texture, aroma, and overall preference, respectively.

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