FORMULATION AND PROCESS OPTIMIZATION OF COMPOSITE GARRI FROM THE BLENDS OF CASSAVA, SWEET POTATO AND BENISEED MEAL

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ABSTRACT

Garri is one of the staple foods in Nigeria made from cassava which have been gelatinized and dried. Research has shown that over 70% of the cassavas produced in Nigeria are processed into garri. This study investigated the formulation of garri made from blends of cassava, sweet potato and beniseed meal. The impact of beniseed roasting temperature, beniseed roasting time, cassava/sweet potato fermentation time, garification temperature and garification time on garri quality were also investigated. Investigations were conducted employing a three-component, five processing parameters, constrained D-optimal mixture-process experimental design with 33 randomized experimental runs. The formulation design constraints were cassava $20\% \leq x_1 \leq 70\%$, sweet potato $20\% \leq x_2 \leq 40\%$ and beniseed meal $10\% \leq x_3 \leq 30\%$. The processing parameters investigated were beniseed roasting temperature $80°C \leq z_1 \leq 150°C$, beniseed roasting time $10min \leq z_2 \leq 20min$, cassava/sweet potatofermentation time$24hr \leq z_3 \leq 72hr$, garification temperature $80°C \leq z_4 150°C$ andtime$min \leq z_5 \leq 25min$. The formulated samples were evaluated for the proximate properties, physical properties and sensory properties. From the numerical optimization through the desirability function, the formulation that produce composite garri of highest desirability index was 50% of cassava, 25.068% of sweet potato, 24.932% of beniseed meal with beniseed roasting temperature of 80°C, beniseed roasting time of 11.26min, cassava/sweet potato fermentation time of 72hr, garification temperature of 80.17°C and garification time of 5min. The proximate properties, physical properties and sensory properties of optimal formulation are as follows; - 9.01% moisture content, 7.88% protein content, 1.41% ash content, 0.90% fibre content, 4.40% fat content, 75.95% carbohydrate content, 147.94% water absorption capacity, 4.01 pH, 200.56% swelling capacity, 0.73g/ml bulk density, 5.77 colour, 6.38 aroma, 6.31 taste, and 5.87 texture and 6.48 overall acceptability.

Keywords: Garri, Optimization, Formulation, Beniseed meal, Sweet potato, Cassava.

1.0 INTRODUCTION

Garri is a free-flowing product, made mainly from cassava which have been gelatinized and dried. In Nigeria, over 70% of the cassava yield is processed into garri (Sanni and Olubamiwa,2004). Composite flour is a mixture of flours, starches, and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products (Noorfarahzilah *et al.*,2014). Composite Garri is the mixture of grated cassava, leguminous crops or rich protein cereals and other ingredients intended to replace grated cassava totally or partially in the production of garri in order to increase the nutritional content of the product.

Cassava belongs to the class Dicotyledoneae, family *Euphorbiaceae,* species *Manihot esculenta Crantz* (Alves, 2002). Cassava (*Manihot esculenta crantz*) is a major food crop in Nigeria, supplying about 70% of the daily calorie of over 50 Million people (Oluwole *et al.*,2004). It has also been estimated that cassava provides food for over 500 Million people in the world, (Abu *et al.*,2006). It is essentially a carbohydrate food with low protein and fat (Ajala *et al.*,2012). Edible part of fresh cassava root contains 32-35% carbohydrate, 2-3% protein, 75-80% moisture,0.1% fat, 1% fibre and 0.75 -2.50% ash (Ajala *et al.*,2012; Oluwole *et al.*,2004). Cassava roots are highly perishable and a lot of post-harvest losses occur to this commodity during storage due to high physiological activities and activities of micro-organisms that entered bruises received during harvesting as well as the inherent high moisture content of fresh roots which promote both microbial deterioration and unfavourable biochemical changes in the commodity (Ajala *et al.,* 2012). The Sweet potato (*Ipomoea batatas (L.) Lam.*) is a dicotyledonous root and tuber crop belonging to the family *convulaceae* (Zhang *et al.,* 2000). Sweet potato particularly provides energy in the human diet in the form of carbohydrates. According to USDA (2009), besides carbohydrates, they are also rich in dietary fibre and have high water content and also provide 359 kJ energy with low total lipid content, which is only about 0.05 g per 100 g. In addition, sweet potatoes also are high in minerals such as potassium, calcium, magnesium, sodium, phosphorus, and iron (USDA, 2009). Because of the various roles that sweet potatoes play around the world, the concept of nutritional quality and its contribution must transform to meet specific roles in human diet. Beniseed (*Sesamum indicum L.*), a member of the *Pedaliaceae* family, is an erect annual herb commonly known as sesamum, benniseed, or simsim. In Nigeria, beniseed occurrence is fairly widespread, borne out by the fact that there are over twenty different names in different languages for the crop (Dia and Gwandi, 2015). It is called Ridi (Hausa), Isasa (Igbo), Ocha (Idoma), Ekuku (Yoruba) etc. Main areas of cultivation in Nigeria are around guinea and sudan savannah zones including large portions of present day Jigawa, Pleateau, Kano, Kastina, Yobe, Gombe, Benue, Kwara, Kogi, Nasarawa, and Niger States, (Faisal *et al.,* 2016 ; Ojiako *et al.,* 2010). Beniseed seeds have both nutritional and medicinal

value because they are rich in fat, protein, carbohydrates, fibre, and essential minerals. They are chemically composed of 44–57% oil, 18–25% protein, 13–14% carbohydrates (Borchani *et al.*, 2010). Beniseed oil is famous for its stability as a result of its resistance to oxidative rancidity after long exposure to air (Global Agri Systems, 2010). Garri is nutritionally inferior with low protein content; there is need therefore to improve the nutritional quality by substituting other nutritionally rich quality crops like the legumes. The major objective of this study is to formulate, via mixture process design, composite garri from blends of cassava, sweet potato and beniseed meal. However, processing parameters play vital role in the final quality of the product. The variable processing parameters considered in this study are beniseed roasting temperature, beniseed roasting time, cassava/sweet potato fermentation time, garification temperature, and garification time.

2.0 MATERIALS AND METHODS

2.1 Collection and Preparation of Samples The major ingredients for this study include cassava, sweet potato, beniseeds. They are obtained from Kure Market, Minna Niger State.

2.2 Equipment and Apparatus

The equipment and apparatus used in the study include stainless steel knife, trays, gas cooker, weighing balance, jute sacks, hydraulic press, plastic containers, thermometer, frying pan, spatula, grating machine, chopping board, oven, petri dishes, crucibles, desiccator, Kjedehl apparatus, muffle furnace, beaker, filter paper, soxhlet apparatus, magnetic stirrer, centrifuge, measuring cylinder, pH meter, conical flask, and thimble.

2.3 Preparation of Beniseed Meal

Beniseeds meal was prepared according to the methods of Ayo *et al.*, (2012). The Beniseeds were thoroughly cleaned to remove stones and other extraneous materials. The cleaned beniseeds were toasted (roasted) at different temperatures and duration as specified in the design matrix (Table 1)

2.4 Preparation of Cassava/ Sweet Potatoes

Cassava and sweet potato tubers were prepared according to the methods of Ojo and Akande, (2013). The cassava and sweet potato were differently sorted, washed and peeled. The different peeled tubers were cut into smaller sizes, grated, dewatered and fermented at different fermentation durations as specified in the design matrix (Table 1).

2.5 Processing of Composite Garri

The milled beniseed meal were incorporated into the fermented cassava and sweet potato mashes at different proportion as specified in the design constraints (Table 2) and sieved together using

hand sieve. After sieving, the composite blends were toasted (garified) in a shallow iron pan at different garification temperatures and time as specified in the design matrix (Table 1) with intermittent stirring until thoroughly gelatinized. The products were removed from the iron pan and spread out on a tray to be cooled before packaging. (See Fig.1)

Table 1; Matrix design

	X1	X2	X3	Z1	Z2	Z3	Z4	Z5
Run	**(%)**	**(%)**	**(%)**	**(°C)**	**(min)**	**(hrs)**	**(°C)**	**(min)**
1	50	20	30	150	10	72	150	5
2	56.667	26.667	16.667	150	20	24	**80**	25
3	60	30	10	150	10	24	150	25
4	50	20	30	80	10	24	150	5
5	70	20	10	80	20	72	80	25
6	50	20	30	150	10	24	80	25
7	70	20	10	80	10	72	150	5
8	50	40	10	150	10	24	150	25
9	50	20	30	150	20	24	150	25
10	70	20	10	150	10	72	80	25
11	53.333	23.333	23.333	115	15	48	115	15
12	70	20	10	150	20	24	150	25
13	70	20	10	80	20	24	150	5
14	50	40	10	80	20	24	80	5
15	70	20	10	150	20	24	80	5
16	50	20	30	80	10	24	150	5
17	56.667	26.667	16.667	150	20	24	150	5
18	50	40	10	80	20	72	150	25
19	50	40	10	150	20	72	150	5
20	70	20	10	80	10	24	80	25
21	50	30	20	80	20	24	150	25
22	56.667	26.667	16.667	150	10	24	80	5
23	56.667	26.667	16.667	80	20	72	150	5
24	50	20	30	80	10	72	150	25
25	50	40	10	80	10	72	80	5
26	60	20	20	80	20	72	80	25
27	50	20	30	80	20	72	80	5

28	60	30	10	150	10	72	80	5
29	50	20	30	80	10	72	150	25
30	50	40	10	150	20	72	80	25
31	50	40	10	150	10	24	150	25
32	50	40	10	80	20	24	80	5
33	50	20	30	80	20	72	80	5

X_1 = Cassava (%)
X_2 = Sweetpotato (%)
X_3 = Beniseed Meal (%)
Z_4 = Garification Temperature (°C)
Z_5 = Garrification Time (Min)

Z_1 = Beniseed Roasting Temperature (°C)
Z_2 = Beniseed Roasting Time (Min)
Z_3 = Cassava/ Sweetpotato Fermentaion Duration (Hrs)

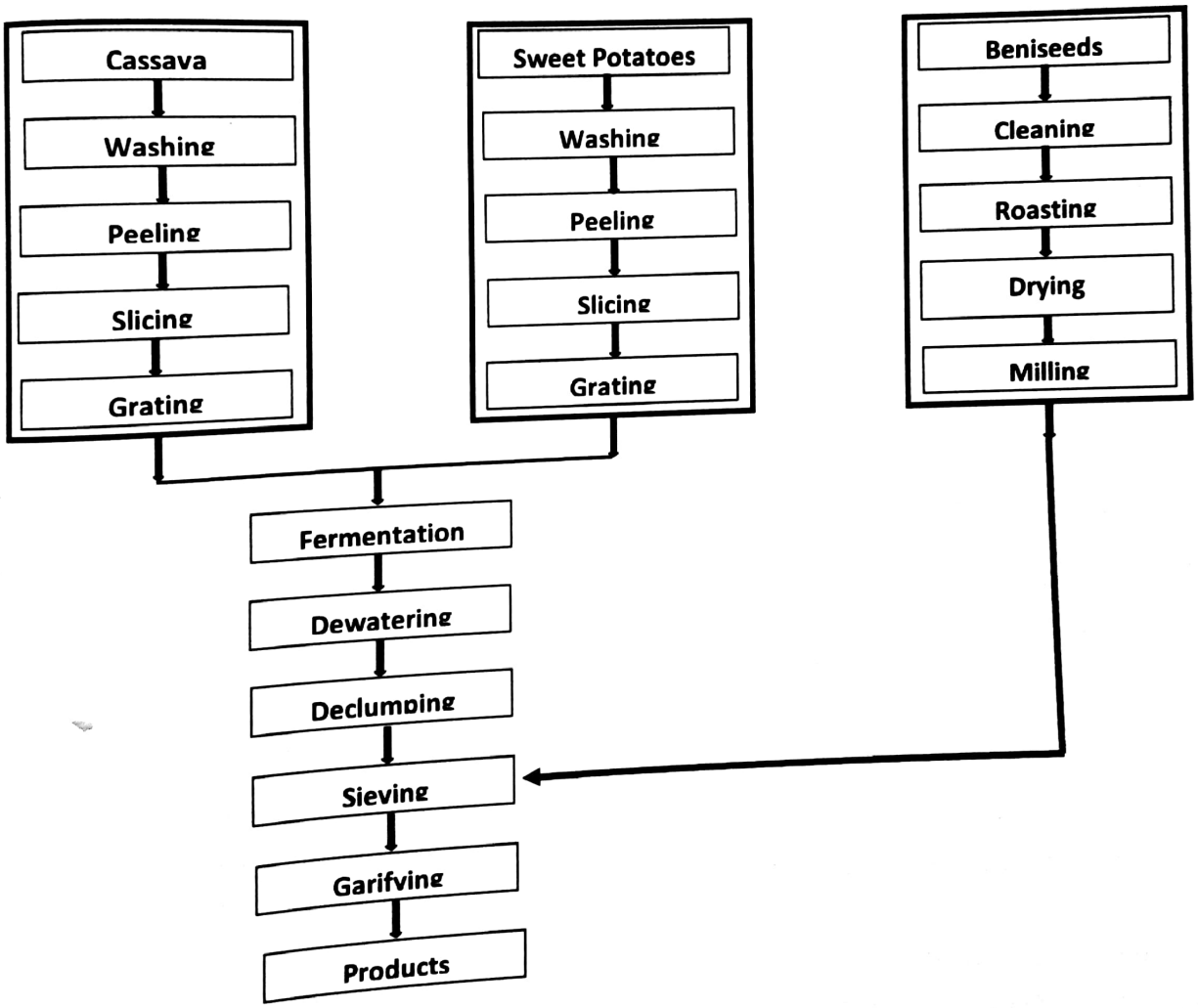

Figure 1: Flowchart of Composite Garri Production

Low	Constraints	High
20	x_1: Cassava (%)	70
20	x_2: Sweet Potato (%)	40
10	x_3: Beniseed meal (%)	30
	$x_1+x_2+x_3$	100

2.6 DESIGN SUMMARY

Table 2; Design constraints for matrix components

Table 3; Design constraints for process variables

Low	Constraint	High
80	z_1: Beniseed RoastingTemperature (°C)	150
10	z_2: Beniseed Roasting Time (min)	20
24	z_3: Cassava/Sweet Potato Fermentation Time (hr)	72
80	z_4: Garification Temperature (°C)	150
5	z_5: Garification Time (min)	25

2.7 Proximate analysis

The moisture content, protein, ash, fat, fibre, and carbohydrate were determined using methods of Association of Official Analytical chemist (AOAC, 2002).

2.8 Physical Properties

Water absorption capacity was determined using the method of Ajala *et al.*, (2012), pH using the method of Nwafor *et al.*, (2015), swelling index with the method of Nwosu *et al.*, (2011), and bulk density was determined using the method described by Nwanekezi *et al.*, (2001).

2.9 Sensory Properties

Sensory evaluation of the samples was conducted using Twenty panelists. A 9-point hedonic scale ranging from 9= like extremely and 1= dislike extremely was used to evaluate the samples

for colour, aroma, taste, texture and overall acceptability. Table water was used for mouth rinsing intermittently to minimize the carry over effects (Akinjayeju, 2010)

2.10 Statistical Analysis

Design expert 11.0 software was employed for both the design and the analysis of the obtained data.

3.0 RESULT AND DISCUSSION

3.1 Results

The overlay contour and the overlay contour – mixture process plots showing the optimized formulation with the respective processing parameters are presented in figures 2 and 3.

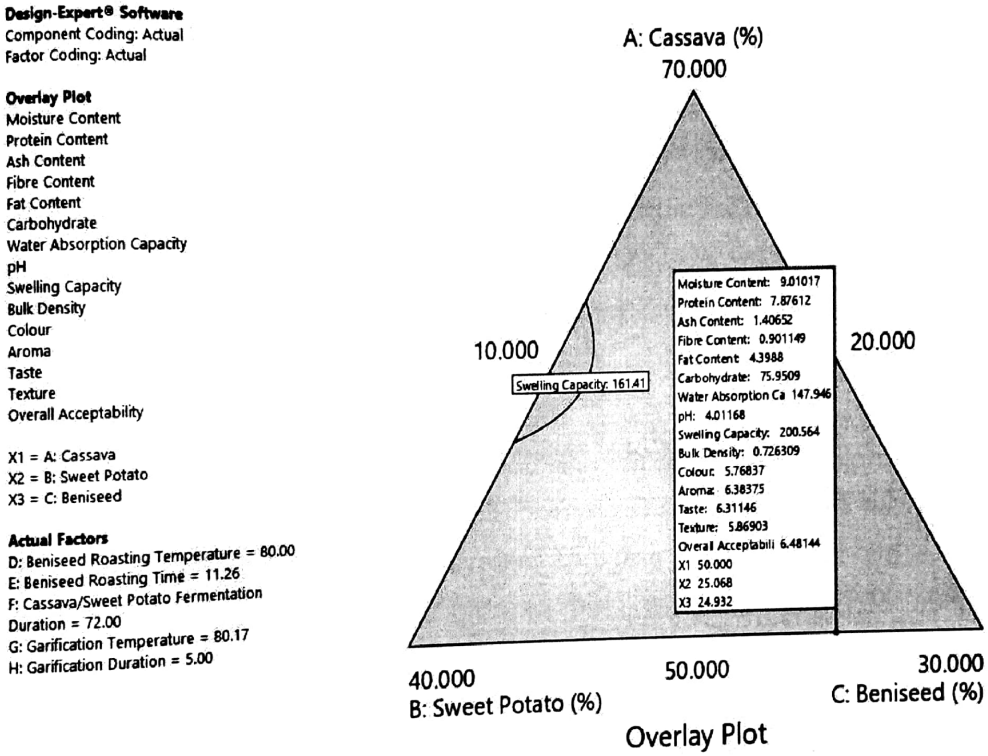

Figure 2: Overlay Contour Plot for the Effect of Formulation of Cassava, Sweet-potato and Beniseed on Desirability.

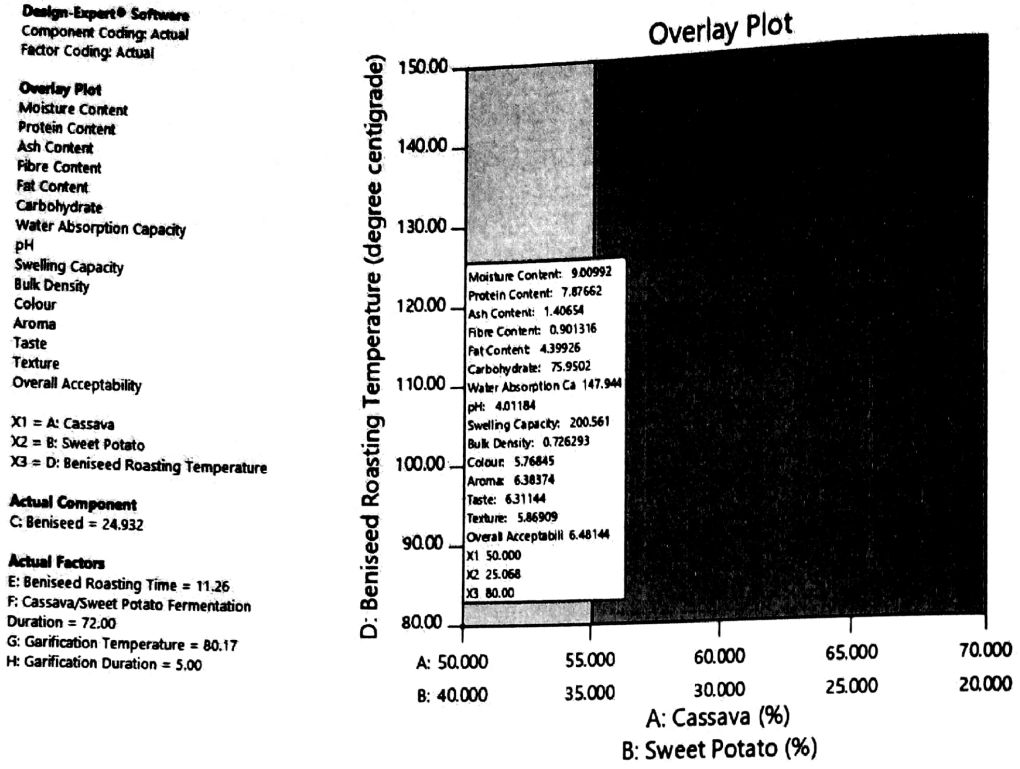

Figure 3: Overlay Contour Mix-Process Plot Showing the Effect of Beniseed RoastingTemperature of the grated Cassava, Sweet-potato on Desirability.

3.2 Discussion

A Numerical optimization method exploiting the desirability technique was utilized to generate the optimal formulation with the anticipated responses. The optimal formulation was obtained based on the criteria of achieving minimum usage of cassava, maximum usage of sweet potato, maximum usage of beniseed, minimum beniseed roasting temperature, minimum beniseed roasting time, targeted cassava/sweet potato fermentation duration of 24hr to 72hr, minimum garification temperature, minimum garification duration, minimum moisture, maximum protein, maximum ash, maximum fibre, minimum fat, minimum carbohydrates, maximum water absorption capacity, minimum pH, maximum swelling capacity, maximum bulk density, maximum sensory properties.

Optimal garri with desirability index of 0.552, based on the individual processing parameters and response desirability indices was obtained. Desirability is an objective function which varies between 0 and 1. The numerical optimization locates a point that maximizes the desirability. The box in the overlay contour indicates the best mixture that gave rise to the best responses. The box on the overlay contour mix-process plot shows the optimal conditions for the composite garri product.

4.0 Conclusion

From the numerical optimization through desirable function, the formulation that produced composite garri of highest desirability index of 0.552 are 50.000% cassava, 25.068% sweet potato 24.932% beniseed meal. The proximate composition of the optimal formulated composite garri obtained are 9.01% moisture content, 7.88% protein content, 1.41% ash content, 0.90% fibre content, 4.40% fat content, 75.95% carbohydrate content. The optimal physical properties obtained are 147.94% water absorption capacity, 4.01 pH, 200.56% swelling capacity, 0.73g/ml bulk density. The Optimal sensory properties rated by the panelists are 5.77 colour, 6.38 aroma, 6.31 taste, 5.87 texture and 6.48 overall acceptability. The optimized garri shows the processing conditions of 80◦C beniseed roasting temperature, 11.26min beniseed roasting Time, 72hours cassava /sweet potato fermentation duration, 80.17C garification temperature and 5.00min garification time.

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Reference

Abu, J. O., Badifu, G. T. O. and Akpapunam, M. A. (2006). Effect of Crude palm oil inclusion on some physicochemical properties of gari –A fermented cassava Food product. Nig. Food J. 24(1): 73-75

Ajala, L., Otutu, O. L. and Bamgbose, A. (2012). Effect of delayed processing on some physico-chemical properties of cassava starch. American journal of food and nutrition. 2(2):31-36, doi;10.5251/aifn.2012.2.2.31.36.

Akinjayeju O. (2010). Statistical Quality Control. A Food Science and Technology Approach. Concept Publication Lagos Nigeria Nigeria 153-176.

Alves, A. A. C. (2002). Cassava botany and physiology. In Hillocks, R. J., Thresh, J. M. and Bellotti, A. C. (Eds), Cassava biology, production and utilization. CABI Publishing, Wallingford, UK, 67-89.

AOAC. (2002). Official Methods of Analysis (30th edition). Washington: Association of Analytical Chemists.

Ayo, J.A., Onuoha, G., Agu, H., Ayo, V. A., Avu, E. O., Sosanya, M. and Adeosun, F. (2012). Effect of added beneseed paste on the quality of millet-based masa. African Journal of

Food Science and Technology 3(10):236-243. Retrieved from http://www.interesjournals.org/AJFST (Accessed 19.07.2017).

Borchani, C., Besbes, S., Blecker, C. H., and Attia, H. (2010). Chemical characteristics and oxidative stability of sesame seed, sesame paste, and olive oils. J. Agri. Sci. Tech. 12, 585–596.

Dia, Y. Z. and Gwandi, O. (2015). Determinant of Beniseed (Sesamum Indicum L.) Production among Beniseed Farmers in Mubi Region of Adamawa State, Nigeria. Journal of Agriculture and Crops, 1(4): 44-49, Retrieved from http://arpgweb.com/?ic=journal&journal=14&info=aims

Faisal I., Rafaqat, A. G., Basharat A., Muhammad A. F., Ling X., Ullah N. and Weijun Z. (2016). Breeding Oil Seed Crops For Sustainable Production. Academic press of Elsevier Researchgate. Pp 135-147, DOI: 10.1016/B978-0-12-801309-0.00006-9(Accessed 11.07.2017

Global Agriculture Systems, (2010). Dehulled and roasted sesame seed oil processing unit. 18th August 2011. Available at http://mpstateagro.nic.in/Project%20Reports%20pdf/Dehulled%20and%20Roasted%20Sesame%20Seed%20Oil%20Processing%20Unit.pdf.

Noorfarahzilah, M., Lee, J. S., Sharifudin, M. S., Mohd Fadzelly, A. B. and Hasmadi, M. (2014). Applications of composite flour in development of food products, 21(6): 2061-2074. Retrieved from: http://www.ifrj.upm.edu.my

Nwafor Obi Emmanuel, Akpomie Oluwabunmi, Erijo Peace Elohor (2015). Effect of Fermentation Time on the Physico-Chemical, Nutritional and Sensory Quality of Cassava Chips (Kpo-Kpo Garri) a Traditional Nigerian Food. American Journal of Bioscience, 3(2):59-63, doi: 10.11.11648/j.ajbio.20150302.16. (Accessed 09.08.2017)

Nwanekezi, E.C., Ohagie, N.C. and Afam-Anene, O.C. (2001). Nutrition and Organoleptic Quality of Infant food formulations msde from natural and solid state fermented tubers (cassava sprouted and unsprouted Yam)- Soybean flours blend. Nigeria Food Journal, 19:55:62.

Nwosu J.N., Ogueke, C.C., Owuamanam, C.I. and Onuegbu, N. (2011). The Effect of Storage Conditions on the Proximate and Rheological Properties of Soup Thickner *Brachystegia enrycoma* (Acha). Report and Opinion,3(5):52-58. (Accessed 08.08.2017)

Ojiako, O.A., Igwe, C.U., Agha, N.C., Ogbuji, C. A. and Onwuliri, V. A. (2010). Protein and amino acid compositions of Sphenostylis stenocarpa, Sesamum indicum, Monodora myristica and Afzelia africana

Ojo, A. and Akande, E. A. (2013). Quality evaluation of 'gari' produced from cassava and sweet potato tuber mixes. African Journal of Food Biotechnology. 12(31), 4920-4924.

Oluwole, O. B.; Olatunji, O. O. and Odunfa, S. A. (2004) A process technology for conversion of dried cassava chips into gari. Journal of Food Science and Technology 22: 65 -77.

Sanni, M. O. and Olubamiwa, A. O. (2004). The effect of cassava post-harvest and fermentation time on garri sensory qualities. Ibadan, Nigeria. Donald Danforth Plant Science Centre, CassavaNet S2-14.

USDA, (U.S. Department of Agriculture), Agricultural Research Service. (2009). USDA National Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, http://www.ars.usda.gov/ba/bhnrc/ndl, Accessed 14 September 2012.

Zhang, D., Cervantes, J., Huaman, E., Carey, E. and Ghislain, M. (2000). Assessing Genetic Diversity of Sweet Potato (Ipomoesa batatas (L.) Lam.) Cultivars From Tropical America using AFLP. Genetic Resour. Crop Evol. 47: 659-665.