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Nutrient Composition and Functional Properties of Powdered Fura Supplemented with Plant Protein Concentrates

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Abstract

Nutrient composition and functional properties of powdered *fura* a cereal based traditional meal supplemented with plant protein concentrates were investigated. Protein concentrates from soybean, cashew nut and groundnut were blended with millet flour at 70:30 (Millet: Protein concentrates) to formulate three samples of *fura* coded as SF (*Soyfura*), CF (Cashew *fura*) and GF (Groundnut *fura*) respectively. Powdered *fura* processed from 100% millet (MF) served as control. Essential amino acids, mineral composition and functional properties of the samples were evaluated using standard method of analysis. Plant protein concentrates significantly (P<005) improved the lysine, threonine and histidine values of formulated *fura*. The total essential amino acid in the formulated samples was 27.1, 28.2 and 29.0 g/100g for CF, SF and GF respectively while the control sample had 23.1 g/100g. Iron, zinc and sodium of formulated samples were higher than those obtained for the control. Water absorption capacity (WAC), swelling capacity (SC) and bulk density (BD) of supplemented samples ranged from 2.7 g/g to 3.00 g/g, 15.11 g/g to 16.00 g/g and 0.64 g/cm^3 to 0.67 g/cm^3 respectively compared to 2.2 g/g, 12.62 g/g and 0.45 g/cm^3 in the control sample while the least gelation concentration was 6% for the formulated samples. The study established that the use of protein concentrates from leguminous sources resulted in significant improvement in the nutrient content and functional properties of *fura*.

Keywords: Fura; Millet; Protein concentrates functional properties.

Introduction

Fura is a semi-solid dumpling cereal-based meal. It is one of the traditional staple foods in West Africa particularly in Nigeria, Ghana and Burkina-Faso [1]. *Fura* is principally produced from millet or sorghum, and blended with spices and water, compressed into dough balls and cooked. The cooked dough balls are broken up and made into slurry by mashing in water before consumption in the form of porridge [2]. *Fura* serves as dietary staple food and beverages for many adults and weaning food for infants [3]. *Fura* in its traditional (dough) form has a limited shelf-life of one to two days at ambient storage.

Attempt has been made in previous research [4] to produce *fura* in powdered form. Despite its importance in the diet of large groups of people in the West African region, being a single cereal food, the main nutritional drawback of *fura* is its low protein content. Protein quality of *fura* is also limited in terms of biological value when compared with animal protein [5,6]. Thus, *fura* is nutritionally deficient. Consequently, consistent consumption of *fura* could lead to protein energy malnutrition (PEM). Protein energy malnutrition is a major problem in Nigeria particularly among the low-income group [7]. In Nigeria, PEM has continued to pose challenges due to low quality protein commonly associated with plant-based single diets and faltering economy which has led to declining import of costly protein rich foods [8]. Protein supply needs to be sustainable, nutritious and environmentally feasible. Therefore, studies on the utilization of plant protein concentrates continue to gain attention to meet with the increasing demand for affordable and acceptable dietary proteins, particularly for the low-income group. Protein concentrates are known to be good sources of the essential amino acids, lysine and threonine which are limiting in millets. Millets on the other hand are good sources of methionine an essential amino acid limiting in oil seeds and legumes. Plant protein concentrates are regarded as valuable sources of ingredients in food systems because of their unique functional properties and enhanced sensory attributes [9]. As a means of resolving issues related to malnutrition associated with extensive consumption of cereal-based meals like *fura*, supplementation of millet with plant protein concentrates could go a long way in improving the nutrient quality of *fura*.

In previous preliminary survey [10], soybean, groundnut and cashew nut were the most preferred plants as protein sources for *fura* supplementation. The present study was carried out to determine the nutrient composition and functional properties of powdered *fura* as affected by supplementation of millet with plant (Soybean, cashew and groundnuts) protein concentrates.

Materials and Methods

Source of raw material, chemicals and equipment

Pearl millet grains (*Pennisetum glaucum*), soybean (*Glycine max L. merill*), groundnut (*Arachis hypogaea*), and spices (Clove, red pepper, ginger) were obtained from *Anyigba* Central Market, in Kogi State, Nigeria. Cashew (*Anarcardiom occidentale*) nut was obtained from Kogi State University Cashew Processing Plant. All chemical reagents were obtained from Kogi State University Central Store. All equipment used was from the Departments of Food, Nutrition and Home Sciences and Biochemistry, Kogi State University, *Anyigba*, Nigeria.

Cleaning and milling of the pearl millet

The raw pearl millet grains were placed in a tray and the chaff and damaged grains as well as stones/pebbles together with all other extraneous matter were removed by hand and discarded. Milling of grains was carried out using Brabender Roller Mill (Ohgduisburg, Model 279002, Germany) equipped with 150μm screen.

Preparation of defatted groundnut flour

Defatted groundnut flour was produced according to the method outlined by *Ogunwolu et al.* [11]. Toasted and winnowed (Testa removed) groundnuts were ground into paste with a laboratory blender. The pastes were extracted with normal hexane three times using groundnut cake to solvent ratio 1:10 (w/v) with constant magnetic stirring for 1 hour. The defatted cake was spread on a stainless tray and put under a fume cupboard for 6h to dry and remove traces of solvent. The cake was ground to obtain flour, packaged in plastic tube and stored at 4ºC until used.

Preparation of defatted cashew nut flour

Defatted cashew nut flour was produced as described by *Ogunwolu et al.* [11]. Toasted and winnowed cashew kernel were ground using a pestle and mortar. The flakes were extracted with n-hexane three times using a flake to solvent ratio of 1:10 (w/v) with continuous magnetic stirring (MLH Remi Mumbai-400053) for 1h. The defatted flakes were spread on a stainless tray and put under a fume cupboard for 6h to dry and remove traces of solvent. The flakes were ground to obtain flour, packaged in plastic tubes and stored at 4ºC until used.

Preparation of defatted soybean flour

Cleaned soybean seeds were steeped in water at 30oC for 24h in a plastic bowl. The seeds were thereafter dehulled using traditional pestle and mortar. After dehulling, the grains were washed and the hulls removed. The dehulled, dried seeds were ground in a hammer mill (Asiko All Double Disc, Nigeria Ltd.) to flour. The flour was delipidized through the soxhlet extraction using hexane as solvent for 3h according to AOAC [12] method.

Extraction of concentrates from soy, cashew and groundnuts

Protein concentrates were produced from defatted soy, cashew and groundnuts flour using modified isoelectric precipitation method described by *Andres et al.* [9]. Protein concentrates were extracted by mixing flour in deionized water using flour to solvent ratio 1:10 and the pH adjusted to 11 with 1M NaOH. The solution was stirred mechanically for 2 h and centrifuged at 3000 g for 15 min. The residue was discarded and the supernatant was adjusted to pH 4.5 by addition of 0.1 N HCl and centrifuged at 3000g for 15 min. The supernatant was discarded and the protein precipitate was washed three times with deionized water and allowed to dry in open air at room temperature for 24h. The dry precipitate was milled in an electric blender and sieved with 150 µm screen size, packaged and stored at 4°C ±1

Sample Preparation

Preliminary sensory evaluation ascertained 30 % substitution level as optimum for plant protein concentrate incorporation in millet-based *fura*. Plant protein concentrates supplemented powdered *fura* were produced by blending protein concentrate flour with millet flour in 30:70 ratio (Protein concentrate: millet flour) to produce groundnut *fura* (GF), Cashew nut (CF) and Soy *fura* (SF) while *fura* produced from 100% millet flour served as control. Figure 1 presents the flow diagram for the production of powdered *fura* supplemented with plant protein concentrates.

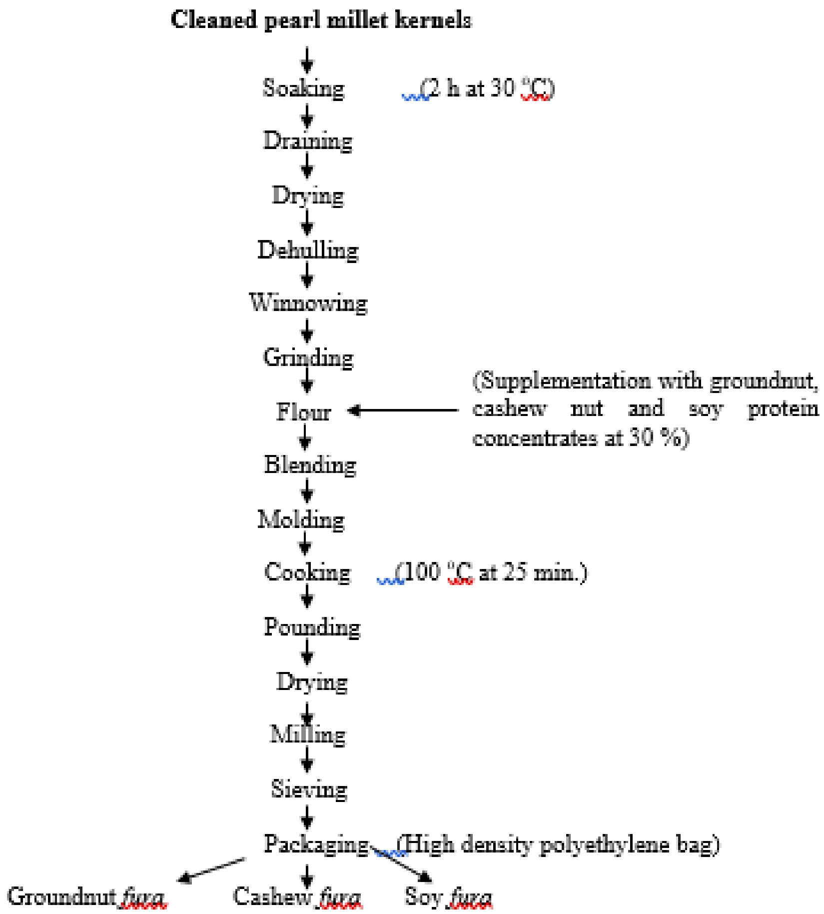

Figure 1: Flow diagram for the production of powdered fura supplemented with three different plant protein concentrates. Study quality and risk of bias assessment

Amino acid analysis and mineral composition

Amino acids composition was determined following the standard methods outlined in AOAC [12]. Mineral composition mineral content (Iron, calcium, magnesium, potassium, zinc and sodium) of the samples was determined using AOAC [12] method. Flour was digested with a mixture of concentrated nitric, hydrochloric and perchloric acid and analyzed using an atomic absorption spectrophotometer (GBC 904AA; Germany). The absorbance was read at 880nm and KH2P04 served as a standard.

Functional Properties

Water absorption capacity (WAC), solubility and swelling power (SP) were determined following the method described by Qingjie et al. [13] with slight modification. Forty millilitre of a 1% sample suspension (by mass per volume) were prepared in a 50 ml centrifuge tube. The tube was placed in a water bath (70oC) for 30 min. The supernatant was decanted and the tubes were inverted and allowed to drain for 5 min on a paper towel.

The swollen granules were weighed. A 10 ml sample was taken from the supernatant, placed in a crucible and dried in an air oven at 120oC for 4 hr to reach constant mass. WAC, solubility and SP were calculated using the following formulae:

$$\text{Water absorption capacity (g/g)} = \frac{\text{weight of swollen granules}}{\text{Sample weight}}$$

$$\text{Solubility (\%)} = \frac{\text{dry weight x 400}}{\text{Sample weight}}$$

$$\text{Swelling power (g/g)} = \frac{\text{weight of swollen granules x 100}}{\text{Sample weight x (100 – solubility)}}$$

Bulk density

The method of *Ijarotimi et al.* [14] was used to determine the bulk density. A graduated cylinder of (10ml) previously tarred was gently filled with the sample. The bottom of the cylinder was gently tapped on the Laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. The bulk density of the samples was calculated as weight of the sample per unit volume of the sample

Gelation capacity

Least gelation capacity was determined according to the method described by *Chinma et al.* [15]. Sample suspensions of 2 to 18% were prepared in distilled water. An aliquot (10 ml) of each dispersion was transferred into a test tube and heated in a boiling water bath for 1 hr, cooled rapidly in a cold-water bath and allowed to cool further at 4^oC for 2 hr. The least gelation concentration was determined when the sample from the inverted test tube did not slip or fall.

Statistical analysis

Statistical package for social sciences (SPSS), Version 20 was used to analyze all data. One-way analysis of variance (ANOVA) and Duncan's multiple range tests were used for comparison of means. Difference between means were considered to be significant when (P<0.05).

Results

Effect of the three different plant protein concentrates supplementation on the essential amino acid profile of powdered *fura*.

The effect of the three different plant protein concentrates supplementation on the essential amino acid (EAA) profile of powdered fura is summarized in Table 1. Lysine, threonine and histidine were significantly (P<0.05) increased by plant protein concentrates supplementation. Substitution of millet with plant protein concentrates however, had no effect on isoleucine and leucine content of fura. Sample GF had higher values of total EAA.

EAA	MF	SF	CF	GF	LSD	FAO/WHO 1989
Isoleucine	2.9^{a}±0.00	2.8^{a}±0.10	2.8^{a}±0.10	2.4^{b}±0.10	0.22	2.8(1.3)
Leucine	8.2^{a}±0.21	10.0^{a}±1.00	10.0^{a}±1.00	10.1^{a}±0.10	0.25	6.6(3.9)
Lysine	1.6^{c}±0.10	2.4^{a}±0.10	2.2^{a}±0.10	2.2^{a}±0.10	0.22	5.8(1.6)
Tryptophan	0.4^{ab}±0.10	0.4^{ab}±0.10	0.4^{ab}±0.10	0.5^{a}±0.10	0.28	1.1(0.4)
Threonine	1.8^{b}±0.11	2.6^{ab}±0.13	2.7^{a}±0.23	3.8^{a}±0.14	0.249	3.4(0.9)
Methionine	1.9^{a}±0.00	1.4^{b}±0.12	1.5^{b}±0.11	1.4^{b}±0.12	0.23	2.5(1.9)
Phenylalanine	2.5^{b}±0.20	2.7^{a}±0.02	2.7^{a}±0.02	2.7^{a}±0.02	0.28	6.3(2.5)
Valine	2.5^{b}±0.52	2.6^{b}±0.13	2.6^{b}±0.12	3.5^{a}±0.52	0.82	3.5(1.3)
Histidine	1.0^{c}±0.00	3.3^{a}±0.21	2.2^{b}±0.23	2.4^{b}±0.10	0.493	1.9(1.6)
Total	23.1	28.2	27.1	29		30.1(16.1)

Table 1: Effect of plant protein concentrates supplementation on the essential amino acid profile of fura (g/100g cP).

Means values with different letters in the same row are significantly (P<0.05) different from each other.

Values in parentheses of FAO/WHO recommended pattern (1989) represents Essential amino acid for adults and numbers outside parentheses represent Essential amino acid for pre-school child (2 – 5 years).

EAA = Essential amino acid

MF = Powdered *fura* from 100% millet

SF = Powdered *fura* supplemented with 30% soy protein concentrate

GF = Powdered *fura* supplemented with 30% groundnut protein concentrate

CF = Powdered *fura* supplemented with 30% cashew nut protein concentrate

Effect of the three different plant protein supplementations on the mineral composition of *fura*

The mineral compositions of formulated *fura* samples and control are presented in Table 2 below. Substitution of millet with protein concentrates obtained from three different plat protein sources at 30% level significantly (P<0.05) increased the Iron and Zinc content of *Fura*. However, plant protein concentrates reduced the calcium content in *fura*.

Sample	**Fe**	**Ca**	**Mg**	**K**	**Zn**	**Na**
MF	0.24d±0.09	46.6a±0.35	116.0b±0.02	160.6b±0.05	0.21d±0.02	9.0c±0.13
SF	2.98b±0.04	40.5b±0.42	143.4a±0.04	175.2a±0.12	0.39b±0.21	11.0b±0.11
GF	3.21a±0.02	30.9d±0.04	75.6d±0.18	139.1d±0.07	0.35c±0.00	13.0a±0.21
CF	2.51c±0.08	30.9d±0.04	79.9c±0.04	146.1c±0.04	0.46a±0.00	11.0b±0.12
LSD	1	1	1	1	0.001	0.064

Table 2: Effect of plant protein supplementation on the mineral composition of fura (mg/100g).

Values are means ± SD of triplicate determinations.

Means on the same column with different superscript are significantly (p<0.05) different from each other.

MF = Powdered *fura* from 100% millet

SF = Powdered *fura* supplemented with 30% soy protein concentrate

GF = Powdered *fura* supplemented with 30% groundnut protein concentrate

CF = Powdered *fura* supplemented with 30% cashew nut protein concentrate.

Functional properties of *fura* supplemented with three different plant protein concentrates

The functional properties of powdered *fura* supplemented with three different plant protein concentrates are presented in Table 3 below. The bulk density was higher in the formulated samples than the control. The water absorption capacity (WAC) and Swelling capacity (SC) of the formulated *fu*ra samples were higher than the control. However, the percentage water solubility of the control sample was higher than the percentage water solubility of the formulated *fura* samples. The least gelation concentrate (LGC) of the protein formulated samples was lower than the LGC of the control samples. Substitution of millet flour with protein concentrates from Soy, ground nut and cashew nut at 30% significantly (P<0.05) increased the bulk density, water absorption capacity and swelling capacity of *fura*, but decreased the water solubility as well as least gelation concentration of *fura.*

Sample	Bulk density g/cm3	Water absorption capacity g/g	Swelling capacity g/g	Solubility %	Least gelation concentration %
MF	0.45c±0.01	2.20c±0.10	12.62c±1.02	22.01a±0.01	8.00a±1.00
SF	0.67a±0.01	3.00a±1.00	16.00a±1.00	16.23c±0.01	6.00b±1.00
GF	0.64b±0.01	2.80b±0.10	15.11b±0.00	18.42b±0.01	6.00b±1.00
CF	0.65b±0.01	2.70b±0.10	15.21b±0.01	18.71b±0.01	6.00b±1.00
LSD	0.001	0.107	0.177	1	0.051

Table 3: Effect of three different plant protein concentrates supplementation on the functional properties of *fura*.

Values are means ± SD of triplicate determinations.

Values followed by the same superscript letter in a column are not significantly (P>0.05) different from each other.

MF = Powdered *fura* from 100% millet (control)

SF = Powdered *fura* supplemented with soyprotein concentrate

GF = Powdered *fura* supplemented with groundnut protein concentrate

CF = Powdered *fura* supplemented with cashew nut protein concentrate.

Discussion

The lysine and threonine values of formulated *fura* samples were significantly (P<0.005) higher when compared with *fura* produced from 100% millet flour. The low content of lysine and threonine observed in the control (MF) is in line with the report of previous researchers who documented that millet is limiting in lysine and threonine [16,17]. The results of lysine and threonine in *fura* formulated with groundnut protein concentrate are comparable with the values reported by Oyarekua and Adeyeye [16] for maize/cowpea ogi – a (Corn gruel traditional complementary food).

The values of valine in control sample (MF), SF and CF formulated samples were comparable but significantly (P>0.05) lower than *fura* formulated with groundnut protein (GF). Sample GF had valine content that compare with the FAO/WHO recommended daily allowance (RDA) for adults and children (Table 1). However, the histidine value was higher in soyprotein formulated *fura* than samples GF, CF and the control. Histidine is essential for infant growth and adult recovering from illness [18].

The total essential amino acid compositions of the formulated *fura* samples were higher than the *fura* from millet flour alone. Ingbian and Adegoke [18] reported that combinations of two or more plant-based food materials usually improved the overall nutrient composition and quality of the food products. Based on the total essential amino acid results presented in Table 1, *fura* formulated with groundnut protein concentrate appeared promising in satisfying the total essential amino acid requirements for both infants and adults.

The iron, zinc and sodium contents of formulated samples (SF, GF, CF) were significantly (P<0.05) higher when compared with control sample (MF). Potassium was found to be the most abundant mineral in both the formulated and control samples. The large amount of potassium relative to sodium in all the samples could be a disadvantage to hypertensive patients because of the mineral imbalance. The increased level of iron and zinc observed in the protein supplemented *fura* is in aggrement with the report of *Beruk et al.* [19] who observed similar increase of iron and zinc in protein/maize based complementary food. Comparing the mineral composition of the formulated samples, the mineral composition of *fura* supplemented with soyprotein concentrate contained higher quantity of minerals than samples GF and CF.

The level of calcium in the control (MF) sample was significantly (P<0.05) higher than the levels of calcium in the protein improved *fura*. This implies that pearl millet flour may contain higher values of calcium than plant protein concentrates. *Samaila et al.* [17] reported that leguminous protein concentrate constitute poor source of calcium.

Supplementation of millet flour with plant protein concentrates in *fura* production, significantly improved the micronutrients (Zn and Fe) values of *fura* across the three samples. Inadequate intakes of micronutrients have been associated with severe malnutrition, increased disease conditions and mental impairment [20]. Findings from the present work suggest that formulated *fura* with plant protein concentrates would contribute substantially to the recommended dietary requirements for minerals.

Supplementation of pearl millet with plant protein concentrates significantly (P<0.05) improved the bulk density (BD) of *fura.* Comparing the bulk density of the formulated samples, sample SF had higher BD than samples GF and CF. Higher BD is desirable for greater ease of dispersibility and reduction of paste thickness which are important properties in convalescent and child feeding [21]. Also, BD is of importance in packaging. The higher BD implies that more quantity of the *fura* sample would be packaged in constant volume thereby ensuring economical packaging.

The significant (P<0.05) increase in water absorption capacity of the formulated samples in the present study, is in agreement with the earlier report by *Chinma et al.* [15]. A number of factors such as hydrophilic-hydrophobic balance of amino acids, protein molecular size and shape influence the WAC of flours. *Li et al.* [22] reported that WAC is important in the development of ready-to-eat foods, as high WAC may assure product cohesiveness. However, the microbial activities of food products with high WAC could be increased. Hence the shelf-life of such product may be reduced.

The swelling capacity is an important factor used to determine the amount of water that food system would absorb and the degree of swelling within a given time *Andres et al*. [9]. The present study showed that the swelling capacities of the protein improved *fura* samples were higher when compared with the control (MF). The trend is in line with the previous reported values for various cereal flours supplemented with oil seed protein flours [14,16,23]. Increase in the swelling capacity of formulated *fura* may be attributed to the decrease in amylose content due to decrease in starch content. Amylose has been reported to act as a dilutor and swelling inhibitor especially in the presence of lipids which can form complexes with some of the amylose during swelling [21]. The high values of swelling capacity imply that more of the formulated *fura* samples would be needed for reconstitution when compared with the control *fura* sample.

Water solubility of formulated *fura* samples decreased significantly (P>0.05) with the inclusion of plant protein concentrates across the three samples. Similar decrease in water solubility was reported for sorghum/cowpea flour and protein/cassava starch [17,24] Extensive cross-linking between protein and starch molecules during heating may have caused the formation of aggregates which rendered the protein insoluble [19].

Least gelation concentration (LGC) of formulated *fura* significantly (P>0.05) reduced. There exist no significant differences in the values of LGC among the supplemented samples. The lower the LGC, the better the gelating ability of the flour.

Conclusion

It is concluded that protein concentrates from soy bean, cashew nut and ground nut have great potential in the formulation of *fura* with improved nutrients and functionality as compared with the conventional *fura*. This study also demonstrated that formulated *fura* samples, particularly *fura* formulated with ground nut protein concentrate can satisfy the total essential amino acid requirements for both infants and adults thereby alleviating cases of malnutrition among the population subsisting on *fura*.

References

Filli KB, Nkama I, Jideani VA, Ibok IU (2012) System parameters and product properties responses during extrusion of fura from millet-soybean mixtures. Nigerian Food Journal 30: 82-100.

Owusu-Kwarteng J, Tano-Debra K, Glover RI, Akabanda F (2010) Process characteristics and microbiology of fura produced in Ghana. Nature and Science Journal 8: 41-51.

James O, Akabanda F (2014) Identification of Lactic Acid Bacteria during traditional fura processing in Ghana. Journal of Food Microbiology 32: 72-78.

Igyor MA, Yusufu PA, Sengev IA (2011) Evaluation of physicochemical, functional and sensory properties of fermented fura powder supplemented with soy. Nigerian Food Journal 29: 113-121.

Khalid B, Vidhu A, Lubna M (2012) Physio-chemical and Sensory Characteristics of Pasta Fortified with Chickpea Flour and Defatted Soyflour. Journal of Environmental Science, Toxicology and Food Technology 1: 34-39.

Ingbian EK, Akpapunam MA (2005) Appraisal of traditional technologies in the processing and utilization of mumu: A cereal-based local food product. African Journal of Food, Agriculture, Nutrition and Development 5: 1-18.

Ogunbusola EM, Fagbemi TN, Osundahunsi OF (2010) Amino acid composition and protein quality of white melon flour. Nigerian Food Journal. 28(1): 7-14.

Onimawo IA, Offurum M (2015) Formulation and nutrient composition of maize pap (Ogi) fortified with ground nut flour. Nigerian Journal Nutritional Sciences 36: 64-71.

Andres C, Pablo DR, Alberto EL (2014) Thermal and rheological behaviour of peanut protein concentrate and starch composites. Journal of American Oil chemistry Society. (91): 1911-1920.

Yusufu PA, Abu JO, Igyor MA, Chinma CE, Onuh JO (2017) Appraisal of fura Processing and Consumption Pattern in Ankpa Local Government Area, Kogi State Nigeria. Indian Journal of Nutrition 2: 1-5.

Ogunwolu SO, Henshaw FO, Mock HP, Matros A (2010) Production of protein concentrate and isolate from cashew. African Journal of Food, Nutrition and Development 10: 2501-2514.

AOAC (1990) Official methods of analysis. Association of Official Analytical Chemists. Washington DC.

Qingjie S, Cuixia S, Liu X (2014) Functional and pasting properties of pea starch and peanut protein isolate blends. Carbohydrate Polymers. 101: 1134-1139.

Ijarotimi OS, Oluwalana IB, Ogunedojutimi MO (2012) Nutrient composition, functional, sensory and microbial status of popcorn-based complementary foods enriched with cashew nut flour. AJFAND 12: 6424-6446.

Chinma CE, Ariahu CC, Abu JO (2013) Chemical composition, functional and pasting properties of cassava starch and soyprotein concentrate blends. Journals of Food Science and Technology 50: 1179-1185.

Oyarekua MA, Adeyeye EI (2009) Comparative evaluation of nutritional quality of functional properties and amino acid profile of co-fermented maize/cowpea and sorghum/cowpea Ogi as infant complementary food. Asian Journal of Clinical Nutrition 1: 31-39.

Samaila J, Anvonye JC, Mudi H, Ede BE, Suleiman JA, et al., (2016) Chemical composition and functional properties of protein concentrate from selected cowpea seeds in Nigeria. EC Nutrition 4: 857-868.

Ingbian EK, Adegoke GA (2007) Quality of protein enriched mumu: a traditional cereal food product. International Journal of Food Science and Technology 42: 385-400.

Beruk BD, Kebede A, Esayas K (2015) Effect of blending ratio and processing technique on physicochemical composition, functional properties and sensory acceptability of quality protein/maize base complementary food. Int'l J. of Food S. Nutrition and Engineering 5: 121-129.

Munemune MA (2012) Chemical composition and nutritional evaluation of cowpea protein concentrate. Global Advanced Research Journal of Food Science and Technology 62: 310-317.

Iwe MO, Onyeukwu U, Agiriga AN (2016) Proximate and Pasting Properties of FARO 44 Rice, African yam bean and Brown cowpea Seeds Composite Flour. Cogent Food and Agriculture 1: 67-79.

Li AJ, Yeh AI, Fan KI (2007) Gelation Characteristics and Morphology of Corn starch/Soy protein Concentrate Composite during heating. Journal of food Engineering. 78: 1240-1247.

Maha AM, Abdullahi HE (2012) Effect of different supplementation levels of soy Soybean flour on pearl millet functional properties. Food and Nutrition Sciences 3: 1-6

Ikegwu OJ, Okechukwu PE, Ekumankana EO (2010) Physico-chemical and pasting characteristics of flour and starch from Achi Seed. Medwell Journal 8: 56-66.