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Chemical composition, functional and sensory properties of maize-based snack (Elekute) enriched with African oil bean seed (*Pentaclethra macrophylla* benth)

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This research work was carried out to evaluate the physicochemical properties of Elekute enriched with African oil bean seed. Elekute (a maize-based snack in West Africa) was substituted with oil bean seed in the ratio 90:10, 80:20, 70:30 and 60:40 with 100% Elekute as control. Results revealed higher protein content with increased substitution (highest was 23.14% in 60:40). Mineral composition as well as the phytic acid, oxalate and tannins in the samples also increased with higher substitution level. There was significant difference among the samples in bulk density, water absorption capacity, oil absorption capacity, emulsion capacity and stability and foaming capacity but no significant difference in gelation capacity. Enrichment of Elekute snack by incorporating African oil bean seed improved the nutritional quality of this maize-based snack with high level of acceptance from the taste panelist.

Key words: Elekute, African oil bean seed (*Pentaclethra macrophylla*).

INTRODUCTION

Maize (*Zea mays* L.) is the most important staple cereal crop in sub-Saharan Africa. It contains approximately 72% starch, 10% protein and 4% fat, supplying an energy density of 365 Kcal/100 g and is grown throughout the world (Ranum et al., 2014). Maize can be processed into a variety of food especially, snacks, such as Aadun (maize pudding), Kokoro (Corn cake), Donkwa (maize-peanut ball) and Elekute (sugared/salted maize flour) (Idowu and Aworh, 2014). Nutritionally, maize is an excellent source of energy (rich in carbohydrate, fat and fibre) and provides many of the vitamins and essential minerals for people in the tropics but low in protein (especially lysine and tryptophan), vitamin B12, vitamin C and n iacin. Consumers of these maize-based snacks in large quantity are faced basically with a large intake of carbohydrate but risk malnutrition and

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vitamin deficiency diseases as well as pellagra which is common in maize-consuming areas (Oyetoro et al., 2007; Lasekan and Akinola, 2002). The need to enrich maize- based snacks with inexpensive quality protein therefore cannot be overemphasized (Idowu and Aworh, 2014).

Elekute is a snack common to West Africa and is produced locally by milling roasted maize into a fine powder to which salt or sugar is added. When oil is added it is known as “Aadun” (Abdurrahman and Kolawole, 2006).

The African oil bean seed (*Pentaclethra macrophylla*: Benth) is a popular tropical tree plant in Nigeria, locally called “ugba” in the eastern part. The Africa oil bean (seeds) is often used to complement carbohydrate foods, vegetables and other foods in Nigeria because it is known to contain a high proportion of protein and the 20 amino acids (Enujiugha and Akanbi, 2005). The oil bean seed is used to supply adequate essential amino acids (protein) needed in diets. The oil bean seed also contains high quantity and quality protein as well as 77-78% unsaturated and 22- 33% saturated fatty acids (Osagie-Eweka and Alaiya, 2014).

African oil bean seed is also known to contain high concentration of phytates, tannins and oxalates (Enujiugha and Olagundoye, 2001) which reports have shown exhibit some favourable effects such as anticarcinogens (Vucenik and Shamsuddin, 2003). Also, Odoemelam (2005) reported high protein content (36.2%) for African oil bean seed. Therefore, incorporating African oil bean seed (AOBS) into maize snack will improve the snack nutritionally.

Producing snack using maize and AOBS will add variety to the existing list of snack food as well as improve the underutilization of AOBS which can substitute other plant protein sources. Therefore, if snacks such as Elekute can be enriched with high protein flour, it will help to increase the amount of protein intake from the snacks consumed and can even serve as daily substitute for food among children (Adebowale et al., 2007).

This study was carried out to evaluate the chemical composition, functional and sensory properties of Elekute (maize-based snack) enriched with Africa oil bean seed flour.

MATERIALS AND METHODS

Raw materials and treatment

The quality protein maize flour and uncultivated African oil bean seeds were purchased from Oja-oba market in Akure, Ondo State, Nigeria.

The African oil bean seeds were sorted, weighed, washed, soaked, dehulled manually and dried (60°C) in an oven. The seeds were milled using hammer mill (model ED-5 Thomas Wiley, England) and sieved with 500 µm mesh sieve. The maize samples were also sorted and milled using 750 µm mesh size. Parts of the maize flour (MF) was substituted with 10, 20, 30 and 40% African oil bean seed flour (AOBSF) by weights. Each blend was separately mixed in a Philip blender (HR2611 model) for three minutes at high speed. The various blends were mixed with salt and packed separately in 100 µm polythene bags and kept in airtight plastic containers under ambient conditions (temperature: 28±2°C, relative humidity: 60%) till needed.

Proximate analysis

Samples were analyzed for moisture, crude protein, total ash, crude fibre and carbohydrate contents by AOAC (2000). Crude protein content was determined by the Kjeldahl-Nitrogen analysis procedure, using 6.25 as a conversion factor, while the crude fat was determined using the Soxhlet extractor. The carbohydrate content was obtained by difference (AOAC, 2000). All analyses were carried out in triplicates

Mineral elements analysis

Mineral content (sodium, potassium, calcium, magnesium, iron, copper and zinc) of the flour samples was determined using an AOAC (2005) method. Sodium (Na) and potassium (K) were determined using the standard flame emission photometer. Phosphorous was determined colorimetrically using the Spectronic 20 (Gallenkamp UK) Kirk and Sawyer (1991) with KH_2PO_4 as the standard. Calcium and magnesium were determined using atomic absorption spectrophotometer (AAS Model SP9, Pye Unicam Ltd, Cambridge, UK). All values were expressed in mg/100 g and determinations were carried out in triplicates (Bamidele et al., 2014).

Functional properties determination

Water and oil absorption capacity was determined by the method described by Abbey and Ibeh (1998). The foaming capacity and stability of the samples were determined using method described by Desphande et al. (1982). Emulsion stability was determined by the method described by Mempha et al. (2007). The method of Onwuka (2005) was adopted in the determination of gelation capacity. A sample suspension of 2.20% (w/v) in 5 ml of distilled water was prepared in test tubes and heated for 1 h in a boiling water bath followed by rapid cooling under cold tap water and later in ice water for 5 min to accelerate gel formation. All tubes were held at 4°C for 3 h. Least gelation concentration was determined as the concentration above which the sample remained in the bottom of the inverted tube.

The bulk density was determined using the procedure of Narayana and Narasinga (1984) with slight modification. Graduated cylinder tubes were weighed and flour sample filled to 5 ml by constant tapping until there was no further change in volume. The contents were weighed and the difference in weight was determined. The bulk density was computed as grams per millilitre of the sample.

Pasting properties determination

The pasting property of the sample was determined according to the Newport (1998) procedure based on 100% dry matter. 3 g of sample was dissolved in 25 ml of water in a sample canister. The sample was thoroughly mixed and fitted into the Rapid Visco Analyser (RVA Super 3, Newport Scientific Pty. Ltd, Australia) as recommended (Newport Scientific, 1998). The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with another 2 min holding time. The 12 min profile was used

Table 1. Proximate analysis of enriched Elekute.

Sample	Total Ash	Crude Fibre	Crude protein	Crude fat	Carbohydrate
100:0	3.37±0.03[d]	3.51±0.04[c]	5.32±0.15[b]	4.16±0.03[c]	78.43±0.02[c]
90:10	2.06±0.04[e]	7.92±0.04[a]	8.26±0.03[d]	6.53±0.02[d]	70.13±0.06[d]
80:20	5.23±0.03[a]	3.85±0.05[d]	15.12±0.08[c]	9.35±0.03[c]	64.75±0.02[c]
70:30	4.64±0.04[b]	5.75±0.04[b]	19.13±0.03[b]	10.88±0.03[b]	55.83±0.03[b]
60:40	3.76±0.23[c]	4.67±0.05[c]	23.14±0.04[a]	14.28±0.03[a]	50.39±0.02[a]

Values are Mean ± SEM; Values with different alphabet within the column are significantly different P<0.05. 100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: oil bean), 60:40 (Elekute: oil bean).

Table 2. Phytochemical composition of enriched Elekute.

Sample	Phytate (mg/100 g)	Oxalate (mg/100 g)	Tannin (mg/100 g)
100:0	3.90±0.07[e]	0.21±0.04[d]	0.05±0.02[b]
90:10	5.10±0.04[d]	0.61±0.04[c]	0.20±0.08[a]
80:20	6.30±0.04[c]	0.62±0.03[c]	0.21±0.03[a]
70:30	7.40±0.08[b]	0.75±0.05[b]	0.24±0.05[a]
60:40	8.10±0.05[a]	0.94±0.02[a]	0.25±0.03[a]

Values are mean ± SEM; Values with different alphabet within the column are significantly different P<0.05. 100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: oil bean), 60:40 (Elekute: oil bean).

and the rate of heating and cooling was at a constant rate of 11.25°C/min. Corresponding values for peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature from the pasting profile were read from a computer connected to the RVA (Ocloo et al., 2010).

Phytochemicals determination

The phytic acid and tannins were determined using the procedure described by Markkar et al. (1993), while AOAC (1990) method was used to determine oxalate. All procedures were carried out in triplicates.

Sensory evaluation

Quality attributes of the "Elekute" made from 100% maize flour substituted with 10, 20, 30 and 40% AOBSF respectively were assessed by a sensory panelist. The panelists were supplied with forms and asked to score the sample using 9-point Hedonic scale with respect to taste, colour, texture, aroma and overall acceptability.

Statistical analysis

All determinations were carried out in triplicate and error reported as standard deviation from the mean. All data were subjected to analysis of variance (ANOVA) and significance accepted at $p \leq 0.05$. The means were separated using Duncan new multiple range test with SPSS package (version 17.0).

RESULTS AND DISCUSSION

Proximate properties

The results of the proximate analysis are presented in Table 1. This showed that the crude protein and crude fat increased with increase in the proportion of the AOBSF level in the 'Elekute' samples. The results indicated that there was a significant difference *(p<0.05)* in the entire samples for all the proximate parameters. Sample 60:40 had the highest protein content of 23.14% and crude fat of 14.28% with corresponding lowest carbohydrate (50.39%), while sample 100:0 (that is, 100% maize) had the least crude protein and crude fat (5.32 and 4.16%, respectively). This is in line with the report of Ayinde et al. (2012) where defatted beniseed was used to enrich a maize based snack. Crude fibre is known to aid the human digestive system. 100:0 had the least value of crude fibre, 3.51% and sample 90:10 had the highest crude fibre content. Ash content of the samples ranged between 2.06 and 5.23%. The low ash content is reflective of the low mineral content of African oil bean seed (Enujiugha and Ayodele-Oni, 2003)

Phyto chemical analysis

This is as presented in Table 2. The phytate, oxalate and tannin contents increased with higher substitution of African oil bean seed ranging from 3.90 to 8.1, 0.21 to 0.94 and 0.05 to 0.25 mg/100 g, respectively with significant difference ($p<0.05$). Phytic acid in cereal based foods inhibit Fe absorption, while high oxalate level in food has been implicated as a cause of kidney stones. Tannins also form insoluble complexes with protein, thus reducing its bioavailability (Chai and Liebman,

Table 3. Pasting properties of enriched Elekute.

Sample	Peak	Trough	Breakdown	Final viscosity	Setback	Peak time	Pasting temperature
100:0	111.08	67.50	43.58	89.33	21.83	5.57	84.35
90:10	118.92	71.50	47.42	94.58	23.08	5.33	83.65
80:20	101.92	69.17	32.75	102.75	33.58	5.42	84.18
70:30	96.08	52.67	43.42	70.75	18.08	4.20	84.85
60:40	141.75	112.33	29.42	165.67	53.33	5.63	85.63

100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: Oil bean), 60:40 (Elekute: oil bean).

Table 4. Mineral analysis of enriched Elekute (ppm)

Sample	P 100:0	Na	K	Fe	Zn	Cu	Mn	Ca	Mg
100%	0.34±0.01[e]	150.0±1.00[a]	54.67±4.04d	0.68±0.01[e]	0.43±0.03[e]	0.02±0.01[a]	0.07±0.01[b]	1.40±0.01[e]	0.50±0.01[c]
90:10	0.46±0.07[d]	145.0±6.56[ab]	65.0±3.61[c]	1.07±0.06[d]	0.55±0.03[d]	0.02±0.06[a]	0.12±0.02[a]	1.50±0.01[d]	0.60±0.01[b]
80:20	0.57±0.09[c]	145.7±2.08[ab]	74.0±2.65[b]	1.36±0.03[c]	0.66±0.03[c]	0.03±0.01[a]	0.12±0.03[a]	1.70±0.01[c]	0.69±0.01[a]
70:30	0.65±0.06[b]	148.0±1.00[ab]	74.0±2.00[b]	1.47±0.06[b]	0.74±0.04[b]	0.04±0.06[a]	0.13±0.04[a]	1.80±0.01[b]	0.69±0.01[a]
60:40	0.72±0.04[a]	143.0±3.61[c]	98.68±0.03[d]	1.66±0.04[a]	0.84±0.02[a]	0.03±0.02[a]	0.13±0.03[a]	1.99±0.01[a]	0.69±0.01[a]

Values are Mean± SEM; Values with different alphabet within the column are significantly different P<0.05. 100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: oil bean), 60:40 (Elekute: oil bean).

2004). Thus, the phytate/oxalate/tannin contents of Elekute enriched with African oil bean seed was highest at 60:40, in line with the report of Enujiugha and Ayodele–Oni, (2003) and Enujiugha and Akanbi (2005) that African oil bean seeds are high in tannins, phytates and oxalates but thermal processing may cause a decrease in the levels of these phyto chemicals. Less than 20% level of substitution with African oil bean seed is therefore desirable.

Pasting properties

The result of the pasting properties of Elekute enriched with African oil bean seed as presented in Table 3 showed that sample 60:40 had the highest peak viscosity (141.75), final viscosity (165.67), setback (53.33), peak time (5.63 min) and pasting temperature (85.63°C). This indicate higher gelatinization temperature and longer cooking time. However, for technical and economic reasons, starches/flours with lower pasting time and temperature may be more preferred when all other properties are equal (Iwuoha, 2004; Baah et al., 2009). A low set back is also an indication that the starch has a low tendency to retrograde or undergo syneresis during freeze/thaw cycles (Ikujenlola and Fashakin, 2005). Thus, sample 70:30 with lowest peak viscosity (96.08), final viscosity (70.75), setback (18.08) and lowest peak time (4.20 min) may be of higher caloric density per unit volume and a preferred choice when pasting properties are being considered in food processing.

Mineral composition

The result of the mineral composition of Elekute substituted with African oil bean seed as shown in Table 4 revealed a corresponding increment in concentration of mineral contents with increase in substitution with AOBS. An earlier report by Enujiugha and Agbede (2000) had concluded

Table 5. Functional properties of enriched Elekute.

Sample	Loose (g/ml)	Pack (g/ml)	WAC (ml/g)	OAC (ml/g)	LGC (%)	EC &S (%)	FC&S (%)
100:0	0.49±0.01[b]	0.75±0.01 [c]	2.30±0.01 [c]	1.20±0.01[b]	3.60±0.01 [a]	1.58±0.01 [c]	5.20±0.01 [e]
90:10	0.51±0.01 [a]	0.79±0.01 [a]	2.50±0.01 [a]	0.99±0.05 [c]	3.60±0.01 [a]	1.59±0.01 [c]	7.07±0.06 [d]
80:20	0.52±0.01 [a]	0.77±0.01 [b]	2.40±0.01 [b]	1.00±0.00 [c]	3.59±0.01 [a]	2.30±0.01 [a]	3.90±0.01 [c]
70:30	0.44±0.01 [c]	0.75±0.01 [c]	2.20±0.01[d]	1.03±0.06 [c]	3.60±0.00 [a]	1.85±0.01 [b]	5.90±0.10 [b]
60:40	0.43±0.01 [c]	0.73±0.01[d]	2.40±0.01 [b]	1.30±0.01 [a]	3.60±0.01 [a]	1.90±0.01 [b]	10.30±0.05 [a]

Values are mean ± SEM; Values with different alphabet within the column are significantly different P<0.05. 100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: oil bean), 60:40 (Elekute: oil bean). Bulk density (loose and pack), water absorption capacity (WAC), oil absorption capacity (OAC), least gelation concentration (LGC), emulsion capacity and stability (ECS), foaming capacity and stability (FCS).

Table 6. Sensory evaluation of enriched Elekute.

Sample	Colour	Taste	Aroma	Texture	Overall acceptability
100:0	8.40±0.97[a]	7.90±0.01[a]	7.60±2.01[a]	8.10±0.99[a]	8.60±0.52[a]
90:10	7.40±0.69[a]	6.30±2.06[b]	6.90±1.45[a]	7.20±1.75[ab]	7.30±0.68[b]
80:20	5.70±1.25[b]	5.20±1.23[b]	6.20±1.14[a]	6.40±1.35[ab]	6.10±1.29[c]
70:30	5.70±1.70[b]	3.00±1.41[c]	6.40±1.65[a]	6.40±2.11[b]	5.00±1.56[d]
60:40	5.40±1.71[b]	3.50±1.27[c]	6.20±1.62[a]	6.90±1.73[b]	4.90±1.45

Values are mean ± SEM; Values with different alphabet within the column are significantly different P<0.05. 100% Elekute (control), 90:10 (Elekute: oil bean), 80:20 (Elekute: oil bean), 70:30 (Elekute: oil bean), 60:40 (Elekute: oil bean).

that African oil bean seed contain appreciable amount of important minerals and this has corroborated with this study. There was significant difference among the samples for phosphorous (P), sodium (Na), potassium (K), iron (Fe), zinc (Zn), calcium (Ca) and magnesium (Mg) while there was no significant difference among the samples for copper and manganese.

Functional properties

Functional properties of food materials are very important for the appropriateness of diet, particularly for growing children (Omueti et al., 2009). Nutritionally, a loose bulk density promotes easy digestibility of food (Osundahunsi and Aworh, 2002), thus from Table 5, the result showed the highest loose bulk density and lowest foaming capacity in sample 80:20 (0.52 g/ml and 3.90%) and lowest bulk density but highest foaming capacity in 60:40 (0.43 g/ml and 10.3%). There is significant difference among samples for all the properties except for least gelation capacity.

Sensory evaluation

As presented in Table 6, the results showed there was no significant difference in aroma for all the samples evaluated but sample 100% Elekute and 90:10 had better colour appeal, while 100% Elekute was rated better for taste, texture and overall, acceptability. Thus, control sample had the best appeal and most acceptable to the panelists. Sample 90:10 is a close substitute as a result of the minimal level of substitution with AOBSF.

Conclusion

Enrichment of Elekute with AOBSF is undesirable beyond 90:10 level of substitution. The effects of the anti-nutrients inherent on the oil bean seed can however be reduced via thermal processing taking advantage of the high protein and mineral contents of the African oil bean seed.

Conflict of Interests

The authors have not declared any conflict of interest.

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