Nutrient/Antinutrient Composition and Sensory Evaluation of Breakfast Cereal produced from Blends of Maize, Millet, Acha with Soybean, Crayfish and Catfish

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ABSTRACT

Background: *Breakfast is an important meal of the day used to end the long night fast. Compared to the same amount eaten at night, breakfast seems to be used more effectively. It provides the fuel needed to start up daily activities.*

Objective: *This study was designed to develop, and evaluate the nutritional, anti-nutritional, and sensory properties of gruel made from maize, millet, acha, soyabean, crayfish, and catfish.*

Methods: *Three composite samples (YSCC=50%yellow maize:25%soybeans:12.5% crayfish:12.5%catfish, MSCC=50%millet:25%soybeans:12.5%crayfish:12.5%catfish, and ASCC=50%Acha:25%soybeans:12.5%crayfish:12.5%catfish) and the control (Control = 100% maize) were assayed to determine the nutritional and anti-nutrient composition and sensory attributes.*

Results: *The results showed that there was a significant difference ($p<0.05$) in the crude protein and crude fibre contents among the four samples. The mineral composition showed significant differences ($p<0.05$) in potassium, sodium, calcium, and phosphorus contents among all four samples. Furthermore, antinutritional factors showed that ASCC had the lowest mean values of phytate (0.18±0.02mg/g), tannin (0.38±0.03mg/g) and oxalate (0.18±0.02mg/g) contents while MSCC had the highest mean values of tannin (0.57±0.02mg/g), trypsin inhibitor (0.89±0.14mg/g) and oxalate (0.27±0.01 mg/g) contents. The sensory evaluation indicated that there was no significant difference ($p>0.05$) among the four blends in terms of taste attributes. Control scored the highest in terms of overall acceptability followed by ASCC.*

Conclusion: *Gruel blends produced in this study had good nutritional profile, sensory qualities, and compared favourably with the control sample (yellow maize only).*

Keywords: Cereals, nutritional component, gruel, antinutrient

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INTRODUCTION

Breakfast is the most significant meal of the day. This is as a result of its quick utilization by the body compared the same amount consumed at night (1). A typical breakfast contains carbohydrate sources (cereals), protein source (mostly dairy), fruit and/or vegetable, and beverage. Breakfast consumption is also believed to optimize the nutritional profile of its consumers providing the key nutrients of public health importance (2). However, indigenous breakfasts which are mostly monocereal grains often referred to as "ogi" are deficient in one or more essential nutrients (3) while conventional cereals, though nutritious, are expensive. There is therefore, a need to improve the nutritional quality of indigenous breakfast by providing a nutritious and healthier alternative.

Breakfast is mainly made from cereals. Cereals are usually low-fat, nutritious food with vital vitamins and minerals like B-vitamins, phosphorus, calcium, and zinc (4). Although cereals are rich in the earlier listed nutrients and also contain the essential sulphur-containing amino acid, methionine, and

cystine, they are poor in lysine (4). This shows the need for augmenting with other sources by making blends. This combination results in the increased nutritional value of the blends as opposed to individual food products(4).

Maize, millet, acha (*Digitaria exilis*), soybean, crayfish, and catfish are food materials with potential nutritional properties. They are readily available in Nigeria. Maize and millet have similar protein content with lysine being the most limiting amino acid (5). Millet is a good source of B-vitamins, calcium, iron, manganese, magnesium, phosphorus, and copper (6). Acha, a variant of millet, is abundant in minerals, iron and fibre but is deficient in threonine and lysine (7). Soybean is a plant source of protein with similar protein quality as animal source protein (8). Crayfish, a seafood, is an excellent and one of the cheapest sources of animal protein in Nigeria. Its muscle fibres are easier to digest compared with other meat products because they are shorter (9). Catfish is another essential source of protein and is traditionally an acceptable part of Nigerian's diet.

The aim of this study is to evaluate the nutrient, anti-nutrient and sensory properties of breakfast cereal made from blends of maize, millet and (acha with soybean, crayfish, and catfish.

MATERIALS AND METHODS

Materials

A 2kg measure of each grains (yellow maize (*Zea mays*), millet (*Pennisetumglaucum*, L), acha (*Digitaria exilis*)), soyabean (*Glycine max*), crayfish (*Procambarusclarkii*) and catfish (*Clarias gariepinus*) were purchased from Orita market in Ibadan, Oyo State, Nigeria.

Methods

The blends were prepared in the Dietetics kitchen, Department of Human Nutrition and Dietetics, Lead City University, Ibadan. 150g of yellow maize, millet, and acha, and 300g of yellow maize for control were sorted for dirt, defects, stones and insects, cleaned and winnowed for chaff, and milled into fine powder using local machine (corona manual grinder with 1.0 Qt high hopper). Milled grains were sieved using a sieve with pore size of 5mm to remove larger bits (>5mm), and smooth flour was stored in opaque airtight container until usage.

Soybeans (225g) was cleaned by removing defective grains, dried pods, stones and other debris. After cleaning, soybeans were dehulled and sundried, and roasted under an open flame in order to reduce the anti-nutritive factors. The roasted soybeans were milled into flour using local machine (corona manual grinder with 1.0 Qt high hopper).

Crayfish was cleaned, sorted, sun-dried, and milled to fine powder using local machine (corona manual grinder with 1.0 Qt high hopper). The powder was sieved with a sieve with pore size of 5mm to remove larger bits to obtain smooth and fine particle sizes, and stored in opaque airtight container until usage.

113g of Oven-dried catfish was cleaned. The flesh was separated from the bones. The fish was therefore, flaked into bits, oven-dried at 160°C. The flakes and bones were milled using local machine corona manual grinder with 1.0 Qt high hopper to obtain smooth and fine particle sizes, and stored in opaque airtight container until usage.

Formulation and Coding of Composite Blends

Maize, millet, acha, soybean, crayfish, and catfish were thoroughly mixed together at a proportion of 50% grains, 25% plant protein, and 25% animal source protein to give quality protein with better amino acid profile and a good source of energy.

The varying proportions yielded 300g of each sample:

YSCC = 50% yellow maize:25% soybeans:12.5% crayfish:12.5% catfish

MSCC = 50% millet:25% soybeans:12.5% crayfish:12.5% catfish

ASCC = 50% Acha:25% soybeans:12.5% crayfish:12.5% catfish

Control = 100% yellow maize (control)

Chemical analysis of samples

The proximate composition analysis (moisture, crude protein, crude fibre, fat, ash, with carbohydrate content calculated by difference) and mineral composition (potassium, sodium, calcium, phosphorus, and iron) as well as anti-nutritional properties (Phytate, Tannin, Trypsin inhibitor, and oxalate) of the samples were determined according to methods described by AOAC (10).

Sensory Evaluation

Sensory evaluation of the breakfast cereals was carried out for the purpose of consumer acceptability and preference using ten (10) semi-trained panelists which consisted of students of Department of Human Nutrition and Dietetics, Lead City University, Ibadan, Oyo State, Nigeria. Panelists were briefed before the commencement of the process and they evaluated the samples based on five (5) sensory attributes such as taste, aroma, appearance, consistency and overall acceptability of

the product. A 5-point hedonic scale questionnaire was used for the five (5) sensory attributes. For taste, 1-Bland, 2-Slightly bland, 3-Neither bland nor sour, 4-Slightly sour, 5-Sour; for aroma, 1-Off-flavour, 2-Mild, 3-Strong, 4-Very strong, 5-Extremely strong; for colour, 1- White, 2-Pale, 3-Slightly brown, 4-Brown, 5-Black; for consistency, 1-Too watery, 2-Watery, 3- Slightly thick, 4-Thick, 5-Too thick; and for overall acceptability, 1-Dislike, 2-Fair, 3-Good, 4-Excellent. The panelists were provided with disposable cups and portable drinking water for rinsing of their mouths in between the assessment of each sample to avoid the transfer of sensory factors from one sample to another(11).

Data and statistical analysis

The triplicate determinations of nutrient, anti-nutrient, and mineral contents were calculated and reported as means and standard deviations. ANOVA was used to test for significant differences at 5% level of significance . Duncan's multiple range test was used to separate means. Data analysis was carried out using SPSS V.23.

RESULTS

Proximate composition of cereal blends

The proximate composition of breakfast cereals formulated from yellow maize, millet, acha, soya bean, crayfish and catfish flour blends are presented in Table 1. The moisture content in the samples ranged from 4.50% to 8.33% and indicated that the Control (8.33±0.29) had the significantly highest ($p<0.05$) moisture content. ASCC on the other hand has the lowest moisture content (4.50±.0.50).

The crude protein and crude fibre content were significantly different ($p<0.05$) in the four samples with MSCC having the highest content (33.52±0.07 and 0.69±0.00 respectively). The crude protein ranged from 13.44±0.04 in ASCC to 33.52±0.07 in MSCC while crude fibre ranged from 0.28±0.00 in ASCC to 0.69±0.00 in MSCC.

The fat content in the samples were significantly different ($p<0.05$) ranging from 3.67±0.58% in ASCC to 10.33±0.58% in MSCC. The ash content of the formulated samples ranged from 1.83±0.29% to 5.50±0.50% and were statistically significant ($p<0.05$). ASCC (1.83±0.29 contained the least ash content while MSCC (5.50±0.50) contained the highest total ash content.

There were significant differences ($p<0.05$) in the carbohydrate content of all the samples as ASCC (76.28±0.83) had the highest while MSCC (44.62±0.34) had the lowest.

Mineral composition of cereal blends

Table 2 presents the mineral composition of breakfast cereals formulated from the blends. The potassium content was significantly different ($p<0.05$) in the four samples. MSCC (732.15±13.98mg/100g) had the highest potassium content while ASCC (471.24±21.35mg/100g) had the lowest potassium content.

Sodium content was significantly different ($p<0.05$) in YSCC (412.42±11.34 mg/100g), MSCC (593.80±11.34 mg/100g), ASCC (382.19±17.32 mg/100g) and Control (499.33±6.55 mg/100g). MSCC had the highest sodium content. Similarly, the calcium content varied significantly ($p<0.05$) in the samples. MSCC (545.16±10.41 mg/100g) had the

Table *1*: Proximate composition of formulated breakfast cereals

Samples	Moisture (%)	Crude Protein (%)	Crude Fibre (%)	Fat (%)	Ash (%)	Carbohydrate (%)
YSCC	5.00±0.50^{b}	24.21±0.04^{c}	0.50±0.00^{c}	7.33±0.58^{b}	4.50±0.50^{ab}	58.46±0.54^{b}
MSCC	5.33±.0.29^{b}	33.52±0.07^{a}	0.69±0.00^{a}	10.33±0.58^{a}	5.50±0.50^{a}	44.62±0.34^{d}
ASCC	4.50±.0.50^{b}	13.44±0.04^{d}	0.28±0.00^{d}	3.67±0.58^{c}	1.83±0.29^{c}	76.28±0.83^{a}
Control	8.33±0.29^{a}	31.61±0.04^{b}	0.65±0.00^{b}	8.00±1.00^{b}	3.67±0.58^{b}	47.74±0.91^{c}

Mean values with the same superscript within the same column are not significantly different ($p>0.05$).
YSCC = 50% yellow maize; 25% soya beans; 12.5% crayfish; 12.5% catfish; MSCC = 50% millet; 25% soya beans; 12.5% crayfish; 12.5% catfish; ASCC = 50% acha; 25% soya beans; 12.5% crayfish; 12.5% catfish; Control = 100% yellow maize

highest calcium content than the other three samples, while ASCC (350.89±15.90 mg/100g) had the lowest calcium content. Phosphorus content in MSCC (873.33±28.87 mg/100g) was significantly different ($p<0.05$) from other samples. However, YSCC (555.00±70.00 mg/100g) and Control (590.00±26.46 mg/100g) were not significantly different ($p>0.05$) in phosphorus content but different from ASCC (155.00±0.00 mg/100g) which had the lowest phosphorus content.

The iron content in YSCC (11.31±0.37 mg/100g), MSCC (11.73±0.55 mg/100g), ASCC (10.06±1.13 mg/100g) and Control (11.90±0.68 mg/100g) were not significantly different ($p>0.05$).

Mean values with the same superscript within the same column are not significantly different ($p>0.05$). YSCC = 50% yellow maize; 25% soya beans; 12.5% crayfish; 12.5% catfish; MSCC = 50% millet; 25% soya beans; 12.5% crayfish; 12.5% catfish; ASCC = 50% acha; 25% soya beans; 12.5% crayfish; 12.5% catfish; Control = 100% yellow maize

Antinutritional composition of cereal blends

Table 3 shows the antinutritional contents of the cereal blends. The phytate content ranged from 0.18±0.02mg/g to 0.36±0.03mg/g. Phytate is an important antinutrient because it inhibits calcium absorption

Table 2: Mineral composition of formulated breakfast cereals

Samples	Potassium (mg/100g)	Sodium (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)
YSCC	508.51±13.98^{c}	412.42±11.34^{c}	378.64±10.41^{c}	555.00±70.00^{b}	11.31±0.37^{a}
MSCC	732.15±13.98^{a}	593.80±11.34^{a}	545.16±10.41^{a}	873.33±28.87^{a}	11.73±0.55^{a}
ASCC	471.24±21.35^{d}	382.19±17.32^{d}	350.89±15.90^{d}	155.00±0.00^{c}	10.06±1.13^{a}
Control	615.67±8.07^{b}	499.33±6.55^{b}	458.43±6.01^{b}	590.00±26.46^{b}	11.90±0.68^{a}

Mean values with the same superscript within the same column are not significantly different ($p>0.05$).
YSCC = 50% yellow maize; 25% soya beans; 12.5% crayfish; 12.5% catfish; MSCC = 50% millet; 25% soya beans; 12.5% crayfish; 12.5% catfish; ASCC = 50% acha; 25% soya beans; 12.5% crayfish; 12.5% catfish;
Control = 100% yellow maize

Table 3: Antinutrient compounds of breakfast cereal blends formulated from yellow maize, millet, acha, soya bean, crayfish and catfish flour blends

Samples	Phytate (mg/g)	Tannin (mg/g)	Trypsin inhibitor (TIAmg)	Oxalate (mg/g)
YSCC	0.36±0.03^{a}	0.43±0.03^{b}	0.10±0.01^{c}	0.20±0.02^{bc}
MSCC	0.25±0.02^{b}	0.57±0.02^{a}	0.89±0.14^{a}	0.27±0.01^{a}
ASCC	0.18±0.02^{C}	0.38±0.03^{c}	0.30±0.00^{b}	0.18±0.02^{c}
Control	0.36±0.02^{a}	0.49±0.02^{b}	0.30±0.00^{b}	0.23±0.03^{b}

Mean values with the same superscript within the same column are not significantly different ($p>0.05$).
YSCC = 50% yellow maize; 25% soya beans; 12.5% crayfish; 12.5% catfish; MSCC = 50% millet; 25% soya beans; 12.5% crayfish; 12.5% catfish; ASCC = 50% acha; 25% soya beans; 12.5% crayfish; 12.5% catfish;
Control = 100% yellow maize

The tannin content of samples ranged from 0.43±0.03mg/g to 0.57±0.02mg/g. These values are higher compared to the values found in the formulated diets by Gemede (12). The trypsin inhibitor content was highest in MSCC which contained millet and soybean.

The oxalate content indicated that MSCC (0.27±0.01a) had the highest and significantly different ($p<0.05$) when compared with the other three samples. YSCC (0.20±0.02bc) shared same similarities with samples C (0.18±0.02c) and D (0.23±0.03b). However, ASCC (0.18±0.02c) and Control (0.23±0.03b) were significantly different ($p<0.05$).

Sensory evaluation of breakfast cereal blends

The result of the mean scores of the sensory attributes of breakfast cereals is presented in Table 4. Based on the taste attributes, there was no significant difference ($p>0.05$) among the samples, however, ASCC emerged as one of the most preferred (2.30±1.16). YSCC (3.00±1.05) and ASCC (2.90±0.99) were considered to have strong aroma. Furthermore, result showed the samples were averagely pale coloured. In terms of consistency, Control (4.90±0.32) was adjudged to be too thick, while other samples were adjudged to be thick. Overall, there was no significant difference ($p>0.05$) among the four samples.

DISCUSSION

This study formulated and determined the nutritional and antinutrient content of cereals (maize, millet, and acha), legume (soybeans) and fish (catfish and crayfish) blends. The proximate composition analysis is the measure of quality of a food substance to ascertain the moisture content, protein, fat, fibre, carbohydrate, fat and other food components. Moisture content is a measure used to evaluate the quality of a food product(13). It is a major factor in storage of food products because it determines the proliferation and thriving of microorganisms(14). The moisture content in the samples ranged from 4.50% to 8.33% and indicated that the control had the significantly highest moisture content but remains within the required 12% limit (14). ASCC on the other hand has the lowest moisture content indicating microbiological safety and stability, hence the possibility of a longer shelf life(15). This result is similar to the findings of Idris et al.(16)

The crude protein and crude fibre content were significantly different in the four samples with MSCC having the highest content of both nutrients. MSCC is a blend of millet, soybean, cray fish and catfish and according to Idris et al., when finger millet is combined with legumes such as soybean, its protein quality is improved(16). The blend of plant sources of protein and cereals are therefore a cheaper and good source of high-quality protein. The fibre content also is within the limit of infant fibre requirement of 2.5% (17). This indicates that this blend can be suitable as a complementary food for infants based on the fibre content.

This fat content of all samples were lower compared to results (11.5%-24.8%) obtained by Solomon who processed cereal from maize, rice, soybeans, acha, benniseed, crayfish, carrot, Bambara nut, and garden egg (18). However, the result form this study

Table 4: Sensory evaluation attributes of the formulated breakfast cereal blends

Samples	Taste (Mean±SD.)	Odour (Mean±SD.)	Colour (Mean±SD.)	Consistency (Mean±SD.)	Overall acceptability (Mean±SD.)
A	2.20±0.79^{a}	3.00±1.05^{a}	2.30±0.82^{ab}	4.00±0.82^{b}	2.60±1.17^{a}
B	2.20±1.03^{a}	2.70±1.06^{ab}	2.90±1.10^{a}	4.00±0.67^{b}	2.80±1.32^{a}
C	2.30±1.16^{a}	2.90±0.99^{a}	2.50±0.97^{ab}	3.70±0.68^{b}	3.00±1.25^{a}
D	1.90±0.88^{a}	1.70±0.68^{b}	1.50±0.53^{b}	4.90±0.32^{a}	3.20±1.55^{a}

Mean values with the same superscript within the same column are not significantly different ($p>0.05$).
YSCC = 50% yellow maize; 25% soya beans; 12.5% crayfish; 12.5% catfish; MSCC = 50% millet; 25% soya beans; 12.5% crayfish; 12.5% catfish; ASCC = 50% acha; 25% soya beans; 12.5% crayfish; 12.5% catfish;
Control = 100% yellow maize

is similar to results (5.95% to 9.94%) from Gemede who formulated complementary food from maize, pea, and anchote flours (12). The variation in results could be due to the varying fat content of the raw materials used in the formulations. The fat content can influence the formulations shelf-life stability due to fat undergoing oxidative degeneration resulting in food spoilage. Furthermore, the ash content in food sample indicates the mineral content of the food sample. For complementary foods, the WHO/FAO recommends that the ash contents should not exceed 5% (19). ASCC in this study exceeds this recommendation by 0.5% while samples A, B and D are within the recommended standards. There were significant differences ($p<0.05$) in the carbohydrate content of all the samples as ASCC (76.28 ± 0.83) had the highest while MSCC (44.62 ± 0.34) had the lowest. ASCC only met the CODEX CAC/GL recommendation (60-75) for carbohydrate content (20). Acha is one of the richest West African cereal and is typically referred to as an "energetic food" –(21).

The potassium content was significantly different ($p<0.05$) in the four samples. Potassium is an important nutrient in maintaining good health by maintaining osmotic pressure, and counteracting the negative effects of sodium on blood pressure, muscle function and electrolyte regulation (22, 23). The sodium content in formulated samples in this study is similar to the results obtained by Edima-Nyah (1). The values of sodium in the samples in this study, except MSCC, is lower compared to the United States Recommended Dietary Allowance (US RDA) of 500mg/100g. Sodium is an important nutrient that requires monitoring especially because of the role it plays in heart health (24).

Calcium and phosphorus are important nutrients in the prevention and treatment of rickets in children, osteomalacia and osteoporosis in adults(22). Calcium is an important nutrient essential for bone and dental health as well as nerve signaling, muscle contraction and the secretion of hormones and enzymes (25). The calcium content varied significantly ($p<0.05$) in the samples. The calcium content in samples in this study is higher compared to the calcium content of formulated diets by Gemede(12). The phosphorus content of samples in this study is similar to the results obtained by Gemede (12) and Ayele et al., (26). The iron content in the samples were not significantly different ($p>0.05$) and are similar to those found by Gemede (12) but higher that those obtained by Solomon (18).

The phytate content ranged from 0.18 ± 0.02mg/g to 0.36 ± 0.03mg/g. Phytate is an important antinutrient because it inhibits calcium absorption. The phytate content in this sample is lower compared to those obtained by Gemede (12) in the developed diets. The phytate content in this sample may not be sufficient enough to inhibit calcium bioavailability and absorption when compared with the results of the phytate content found by Gemede (12) and the suggested critical levels for the molar ratio of phytate and calcium (27). Phytate also inhibits iron bioavailability, however, the values obtained in this study are below the critical levels that can reduce iron bioavailability (27). Zinc can also be inhibited by phytate present in food products. A food product can only be a source of dietary zinc depending on the levels of zinc and zinc inhibiting factors present.

The tannin content of samples ranged from 0.43 ± 0.03mg/g to 0.57 ± 0.02mg/g. These values are higher compared to the values found in the formulated diets by Gemede (12). Tannins reduces protein digestibility by forming insoluble complexes. It also decreases palatability, causes intestinal tract damages and enhances carcinogenesis (28). The tannin content in this study is higher compared to results by Obaroakpo et al. (28) in raw, extruded and fermented extruded flour blends. The trypsin inhibitor content in samples ranged from 0.10 ± 0.01 to 0.89 ± 0.14. Trypsin inhibitors are endogenous enzymes that form stable complexes with proteolytic pancreatic enzymes. These complex formations inhibit the activity of these enzymes (29). The trypsin inhibitor content was highest in MSCC which contained millet and soybean. The oxalate content indicated that MSCC had the highest and significantly different content when compared with the other three samples.

The sensory properties of food samples are major determinants of the perceived quality of the food product. Based on the taste attributes, there was no significant difference among the samples, but ASCC emerged as one of the most preferred. YSCC and ASCC were considered to have strong aroma. Furthermore, in terms of consistency, the control was considered to be too thick, while other samples were adjudged to be thick. This implies that the addition of soybeans, crayfish and catfish affected the consistency of the grains especially as seen compared to the control and YSCC. Overall, there was no significant difference among the four samples indicating that the gruel is generally acceptable to all participants.

CONCLUSION AND RECOMMENDATION

The results of this study show that the gruels had good nutritional profile comparable with the control and are suitable for consumption as breakfast cereals. This can also be a means to achieve nutrition security in households. However, acceptance among children cannot be ascertained, and thus, studies can be conducted to ascertain the acceptance of these gruels among children.

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