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Production and Evaluation of Breakfast Cereals From Blends of African Yam Bean (*Sphenostylis Stenocarpa*) Flour and Corn (*Zea Mays*) Flour

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Abstract

Breakfast cereals from blends of African yam bean (*Sphenostylis stenocarpa*) and corn (*Zea mays*) flours were produced and evaluated. African yam bean (AYB) flour was obtained by steeping the grains, boiling, dehulling, milling and sieving. Corn flour was obtained by conditioning the grains, coarse milling, degerming, fine milling and sieving. Six samples were obtained by mixing AYB flour and corn flour in the ratios of 100:0, 0:100, 60:40, 50:50, 40:60, 30:70 respectively. Each of the flour samples was wetted with water and slightly kneaded to form dough, the dough was extruded and toasted at 180 ^{0}C for 10 min. Weetabix, a known commercial breakfast cereal was used as control. The functional properties, proximate composition, gross energy, calcium and potassium contents and organoleptic properties were assessed. The result showed that 100% AYB flour breakfast cereal is high in protein (21.40%) and fat (11.30%) but low in carbohydrate (37.70%) and gross energy (339.10 kCal/100 g) and 100% corn flour breakfast cerael is high in carbohydrate (72.14%) but low in protein (8.19%), fat (2.7%) and energy (345.62 kCal/100 g). Both 100% AYB and 100% corn flour breakfast cereals were rejected by the judges. Breakfast cereals from AYB-corn flour composite blends were all accepted. The breakfast from the composite blends also had higher protein (13.57-14.19%) than the control (9.19%), higher fat (6.10-6.50%) than the control (3.80%), higher crude fibre (4.30-4.90%) than the control (2.10%) and higher calcium (339.37-482.14 mg/100 g) than the control (100.08 mg/100 g). Energy value however, did not differ significantly (p>0.05) from that of the control. The production and commercialization of the breakfast cereals from the composite flour blends of 50% AYB and 50% corn flour which had the optimum quantities of all the attributes tested is recommended.

Keywords: Breakfast cereals, African yam bean flour, corn, acceptability.

Introduction

A breakfast cereal is a processed food manufactured from cereal grains intended to be eaten as a main course. Breakfast cereals are defined as food obtained by swelling, grinding, milling or flaking of any cereal (Sharma and Caralli, 2004). They can be categorized into traditional cereal that requires further cooking before consumption and ready-to eat cereals that can be consumed from the box. Ready-to-eat breakfast cereals are gradually displacing most traditional diets that serve as breakfast due to ease of preparation and convenience, nutritional value, improved income by consumers, busy schedules and job demands especially amongst urban dwellers (Okafor and Usman, 2015). It is usually served with milk during the morning meal. These days, consumption of ready-to-eat cereals has also been extended to non-breakfast hours and often serve as in-between meals. A study has clearly shown that 42% of 10-year-olds and 35% of young adults consumed cereal at non-breakfast occasions (Okafor and Usman, 2015), and could be taken dry as snack food, with or without cold or hot milk, based on their location, availability of resources and habits. The common breakfast cereals in Nigeria include NASCO Cornflakes, Good Morning oats, Good morning corn flakes, Kellogg's cornflakes, NABISCO flakes, Weetabix, Quaker Oats, Rice crisps, Golden Morn among others.

Results from previous studies indicated that most cereals are limited in some essential amino acids especially lysine and as such, they cannot effectively provide the nutrients required by the body (Onweluzo and Nnamuchi, 2009). Animal products such as meat, eggs, milk, and cheese are known to contain the essential amino acids that could complement this deficiency in cereal foods, but most developing countries do not rely on animal product for their protein needs as a result of economic reason. Whole maize contains about 11% protein, 4% fat, 3% fibre, 65% of starch and other carbohydrates and 1.5% of minerals (Okafor and Usman, 2015). Results from previous studies indicated that maize grain as most cereals, is limited in some essential amino acids especially lysine and tryptophan (Onweluzo and Nnamuchi, 2009). Thus maize alone cannot effectively provide the nutrients required by the body, especially in the morning when the supply of nutrients from the previous day is exhausted. In recent times, food product developers have added legumes into traditional cereal formulation as a means of fortification to prevent malnutrition among the growing population which regularly ingest breakfast cereals. Legumes are rich in lysine and tryptophan. Hence, blending legumes with cereals such as maize will result in improvement of the nutritional value of the resulting blend.

A variety of legumes, including African yam bean (*Sphenostylis stenocarpa*) are underutilized (Udensi *et al*., (2010). African yam bean is a climbing legume with exceptional ability for adaptation to low lands and takes about five to seven months to grow and produce mature seeds. The seeds could be brown, white, speckled or marbled with a hilum having a dark-brown border. African yam bean can be consumed as dry cooked seeds or tuber. Most times, the seed are either added to soups, made into sauce or milled into flour (Amoatey, 2001).

The African yam bean is grown in countries of West Africa such as Cameroon, Cote D'ivoire, Ghana, Nigeria and Togo (Klu *et al*., 2001). The tuber grows as the root source, while the yam bean develops into pods containing 20-30 seeds found above the ground. The seeds form a valuable and prominent source of plant protein. M̀baeyi (2005) reported the proximate composition of African yam bean to include 19.2% crude protein, 1.5% crude fat, 3.8% ash, 8.1% crude fibre, 65.4% total carbohydrate at 10.1% moisture. African yam bean has been reported to have equal or higher lysine content than that of soybean while most of the other essential amino acids correspond to the WHO/FAO recommendation (Yetunde *et al.*, 2009).

The conventional breakfast cereals are very expensive (Okafor *et al*., 2017). They are also carbohydrate based and lack other vital nutrients like protein and minerals such as calcium and potassium which are vital for good health. Calcium is needed for proper development of bones and teeth, for proper functioning and contraction of muscles and nerves, to regulate blood pressure, for secretion of hormones and for blood clotting around wounds (Pravina *et al*., 2013). Continuous poor intake of calcium from the diet makes the body to obtain its calcium needs from the bones which at the long run will result is osteoporosis, a condition characterized by weakness of bones. This condition is on the increase especially in poor countries where milk and other key sources of calcium are not affordable. Potassium is needed to reduce blood pressure, regulate heart function, for normal nerve and muscle functions, conversion of glucose to glycogen, normal fluid balance and to maintain acid/alkaline balance (Stone *et al*., 2016). Fruits and vegetables are the main sources of potassium (Weaver, 2013). The change in diets these days with the consumption of more of processed foods and fewer fruits and vegetables has resulted in increase in daily sodium intake and decrease daily potassium intake which has affected sodium to potassium ratio (Weaver, 2013). The aim of this study was to produce, evaluate and compare breakfast cereals produced from the blends of corn and African yam bean flours with the popular breakfast cereal in the market of foreign origin in terms of functional properties, proximate composition, gross energy content, calcium and potassium compositions and consumers' acceptability. This research therefore has the potential to address the problems of protein-energy malnutrition, micronutrient deficiencies as well as food insecurity through the use of locally available, cheaper and underutilized seeds. It will stimulate establishment of food industries for the production of breakfast cereals and create other marketing and employment opportunities.

Materials and Methods

Material Procurements

African yam bean seeds *(Sphenostylis stenocarpa)* and sound corn grains (*Zea mays*) were obtained from Enugu main market, Enugu State, Nigeria. A locally fabricated single food extruder was obtained from the Food Science and Technology laboratory, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Processing of Corn grains into flour

The method used was a modification of the method described by Okaka (2005). Five kilogram (5 kg) of corn was cleaned and sorted after which it was conditioned by sprinkling with 5% distilled water, then it was coarse milled, after which winnowing was carried out to separate the germ and bran. The grits were fine milled and sieved (0.3 mm sieve aperture) to produce corn flour.

Production of African yam bean

This was done using the procedure described by Olawuni *et al.* (2013). Five kilogram (5 kg) of cleaned African yam bean (AYB) seeds was washed throughly and then soaked in potable water in a stainless steel basin for 24 h so as to soften the seed coat. After soaking, the water was drained. The seeds were boiled for 30 min and then dried using a laboratory oven (Gulfex Scientific DHG 9202, England) at 55 ^{o}C for 12 h to remove moisture and enhance milling operation. The dried seeds were then manually dehulled and the chaff seperated. The dehulled seeds were dry milled into powder using a locally fabricated attrition mill and seived (0.3 mm sieve aperture) to get African yam bean flour.

Production of Composite Flour/ Experimental Design

The experimental design used was a completely randomised design. Composite flour was formulated by mixing Afican yam bean flour and corn flour at the ratios of 60:40, 50:50, 40:60, 30:70, 100:0, 0:100 respectively to give 6 samples. Weetabix, a known commercial breakfast cereal of foreign origin was used as control. Weetabix was chosen due to the current belief in superior nutritional and sensory qualities of foreign products compared to indiginous products by the consumers. The 100:0 and 0:100 formulations were included to assess whether the two flours can independently be used as breakfast cereals.

Breakfast Cereal Production

The breakfast cereal was produced by manually mixing the flour sample (100 g) with cold potable water (28 ^{0}C) in a bowl to form a dough. The dough was allowed to rest for 20 min. This was followed by steaming at 100 ^{0}C for 5 min after which it was allowed to cool to the laboratory ambient temperature (29 ^{0}C±2). The dough was extruded using a locally fabricated extruder with die hole diameter of 6 mm. It was mildly crumbled, laid in a tray and toasted using microwave oven (LG mini oven) at 180 ^{0}C for 10 min. The toasted cereals were left to cool to the laboratory ambient temperature (29 ^{0}C±2) which was followed by packaging in plastic bottles.

Determination of Functional Properties

Bulk Density Determination

Bulk density was determined for each of the formulated samples using the method described by Odo and Ishiwu (1999). Each sample was slowly filled into l0 ml measuring cylinder. The bottom of the cylinder was gently tapped on a laboratory bench until there was no further diminution of the sample after filling to l0 ml mark. Bulk density was estimated by dividing the mass with the volume of the sample (g/ml). Triplicate measurements were taken.

Determination of Gelation Capacity

The gelation capacity was determined using the method described by Odo and Ishiwu (1999). Ten percent (w/v) suspension of each of the samples was prepared in 5 ml distilled water in test tubes. The sample test tubes were heated for 1 h in a boiling water bath which was followed by rapid cooling under running cold tap water. The test tubes were further cooled for 2 h at 4 ^{0}C. The least gelation concentration was determined as that concentration at which the sample from the inverted test tube did not fall down or slip visually.

Determination of Viscosity

The viscosity of the samples was determined using the method described by Onwuka (2005). Five grammes of each formulated samples were suspended in distilled water and mechanically stirred for 2 h at room temperature. Oswald type viscometer was used to measure the viscosity of the mixture.

Determination of Proximate composition and Energy Content

The crude protein (Kjeldahl N x 6.25), fat (solvent extraction with petroleum ether), crude fibre, ash and moisture contents was determined according to the methods of AOAC (2010). The carbohydrate was calculated by difference. The gross energy value was calculated by Atwater formula using the factors of 4.0 kCal for carbohydrate and protein and 9.0 kCal for fat.

Determination of Calcium and Potassium Contents

The mineral contents of the formulated samples were evaluated using the method described by Adedeye and Adewoke (1992). One gram of dried sample was digested with 2.5 ml of 0.03 N hydrochloric acid (HCl). The digest was boiled for 5 min, allowed to cool to room temperature (30 ^{0}C±2) and transferred to 50 ml volumetric flask and made up to the marked level with distilled water. The resulting digest was filtered with ashless Whatman No. 1 filter paper. Filtrate from each sample was analyzed for calcium and potassium contents using an Atomic Absorption Spectrophotometer (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Nowalk, Connecticut, USA) using standard wavelengths. The real values were extrapolated from the respective standard curves. Values obtained were adjusted for HCl-extractability for the respective ions. All determinations were performed in triplicates.

Sensory Evaluation

The formulated samples and the control (Weetabix) were served to 20 panelists consisting of students of Nnamdi Azikiwe University, along with Weetabix (commercial control) using a 9-point hedonic scale (1=dislike extremely, 9=like extremely). The samples were served with milk and were assessed for appearance, aroma, taste and texture. The overall acceptability was calculated with weighted arithmetic mean as described by Ukpong *et al*. (2017), given the following weight to each attribute: Visual appearance 35%, taste 20%, aroma 15%, and texture 30%.

Statistical Analysis

The data obtained from each of the parameters evaluated were further subjected to a one-way Analysis of Variance (ANOVA). The Least Significant Difference (LSD) test and Duncan Multiple Range Test were used to determine significant differences between means and to separate means respectively at $p<0.05$ levels using SPSS package version 17.0.

Results and Discussion

Functional Properties

The result of evaluation of the functional properties of the developed breakfast cereals is presented in Table 1. The bulk density of the control was 0.22 g/ml, but in the developed breakfast cereals, they ranged from 0.44 g/ml to 0.63 g/ml all of which were higher than and significantly different from the control at $p<0.05$. The highest value was found in the sample with 30 AYB:70 Corn Flour formulation. These values were lower than the range of 2.45 and 2.60 g/ml reported by Agunbiade and Ojezele (2010) for fortified breakfast cereals made from maize, sorghum, AYB and soybeans.

Table 1: Functional properties of breakfast cereals

Sample (%AYB:%CF)	Bulk Density (g/ml)	Viscosity (cps)	Least Gelation (%)
100:0	0.44^{c}±0.01	31.09^{a}±0.01	6.00^{b}±0.01
0:100	0.61^{a}±0.00	30.56^{a} ±0.01	6.00^{b}±0.00
60:40	0.58^{ab}±0.01	21.98^{b}±0.10	5.80^{b}±0.01
50:50	0.56^{b}±0.01	16.93^{c}±0.10	6.00^{b}±0.02
40:60	0.54^{b}±0.01	19.73^{b}±0.10	6.00^{b}±0.01
30:70	0.63^{a}±0.12	32.53^{a}±0.10	6.00^{b}±0.02
Control	0.22^{d}±0.01	22.22^{ab}±0.10	8.00^{a}±0.00

Values are means ±SD of triplicate determinations. Values with different superscripts along the same column are significantly different ($p<0.05$).
AYB= African Yam Bean Flour; CF= Corn Flour; Control= Weetabix

However, Mbaeyi (2005) recorded values that were similar to those obtained in this study (0.5341-0.7267 g/ml). The bulk density of the product is a factor that influences the packaging space. The less the bulk density, the more packaging space is required (Agunbiade and Ojezele, 2010).

The values of viscosities were generally low. The viscosity of the control was 22.22 cps, but the viscosities of the samples were in the range of 19.73 to 32.53 cps. Sample 50:50 had the least value while the sample with 30% AYB flour and 70% corn flour (30:70) had the highest. The possible reason for the general low viscosities observed in this work could be due to less disruption of intermolecular hydrogen bonds which resulted in reduced swelling of the granules and gelation (Ihekoronye and Ngoddy, 1985).

The gelation capacity of the formulated samples varied from 5.80 to 8.00% with the highest value found in the Weetabix (control) sample. There was no significant difference amongst the formulated samples. A gel can represent a transitional phase between solid and liquid states. In food systems, the molecular net consists of proteins, polysaccharides or a mixture of both, while the liquid is usually water. Ionic strength, pH and the presence of non-protein components can influence the gelation properties (Tan *et al*., 2014).

Proximate Composition

The proximate composition of the breakfast cereals is presented in Table 2. The moisture content of the control was 7.45%. Apart from the sample containing only AYB flour (100:0) whose moisture content was 14.6%, the rest of the samples had low moisture content in the range of 6.05 to 10.40%. Agu *et al*., (2015) also reported the same range of moisture on composite flour breakfast cereal. Sample containing only corn flour (0:100) had the lowest moisture content. The low moisture content as observed in the AYB-corn flour composite flour samples (60:40, 50:50, 40:60 and 30:70) may be advantageous in prolonging the shelf life of the products if properly packaged.

The lowest value of protein (8.19%) was recorded for sample that contains only corn flour. This value however, did not differ significantly (at $p>0.05$) with that of Weetabix, a commercial breakfast cereal, which was used as control. Samples that contained AYB flour had protein values in the range of 10.95 to 21.45% which were higher than and significantly different from the control, the highest was found in the sample with only AYB flour. Obatolu *et al.* (2001) reported protein values for raw AYB in the range of 20-23% which is similar to that reported for 100% AYB flour (100:0) in this work. The protein content increased with increase AYB flour in

Table 2: Proximate and energy compositions of the breakfast cereals blends.

Sample (%AYB:%CF)	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Carbohydrate (%)	Ash (%)	Energy (kCal/100g)
100:0	14.60^{a}±0.10	21.45^{a}±0.10	11.30^{a}±0.10	4.00^{b}±0.03	37.90^{c}±0.10	4.85^{a}±0.10	339.10^{b}
0:100	6.05^{c}±0.30	8.19^{c}±0.02	2.70^{c}±0.10	8.35^{a}±0.10	72.14^{a}±1.00	1.90^{c}±0.05	345.62^{b}
60:40	10.40^{b}±0.10	14.19^{b}±0.02	9.50^{a}±0.50	4.35^{b}±0.10	57.61^{b}±0.04	3.90^{ab}±0.10	372.70^{a}
50:50	9.85^{b}±0.10	14.05^{b}±0.03	8.20^{a}±0.10	4.90^{b}±0.05	58.95^{b}±0.05	3.05^{b}±0.30	365.80^{a}
40:60	9.86^{b}±0.50	13.67^{b}±0.09	7.30^{ab}±0.10	4.30^{b}±0.05	61.0^{b}±0.06	2.80^{b}±0.05	364.38^{a}
30:70	9.80^{b}±0.20	13.57^{b}±0.18	6.10^{b}±0.10	4.70^{b}±0.03	63.55^{b}±0.16	2.55^{b}±0.10	363.38^{a}
Control	7.45^{c}±0.00	9.19^{c}±0.05	3.80^{c}±0.10	2.10^{c}±0.10	74.96^{a}±0.09	2.50^{b}±0.20	370.80^{a}

Values are means ±SD of triplicate determinations. Values with different superscripts along the same column are significantly different ($p>0.05$).
AYB= African Yam Bean Flour; CF= Corn Flour; Control= Weetabix

The AYB-corn flour composite blends. The incorporation of legumes into cereal meals has been reported to result in a higher protein quality than if administered as only cereal meal (Philip and Itodo, 2000). The protein contents of AYB-corn flour samples were all higher than and significantly different from the control (at $p<0.05$). The high protein content of the products may be attributed to the presence of African yam bean (AYB) flour used in the formulations. Thus, production of breakfast cereals with blends of AYB and maize flour may be one way of combating the problem of protein energy malnutrition which is presently ravaging a lot of low income countries.

The fat content of the control was 3.80%, that of the sample containing only corn flour was 2.10% while the one containing AYB alone was 11.30%. The fat contents of AYB-corn composite flour samples were in the range of 6.10 to 9.50% all of which were significantly higher than the commercial Weetabix (control). This showed that the formulated breakfast composite flours were high energy products because of the fat content. These high fat content may increase the energy value of the formulated breakfast cereals, since 1 g of fat yields 9 kCal of energy.

The crude fibre of the control was the lowest (2.10%). Sample containing only corn flour had the highest value of crude fibre (8.35%) while that of AYB-corn composite flour blends were in the range of 4.00 to 4.90%. It is known that whole grains are good source of dietary fibre and are used in the prevention and treatment of constipation, cardiovascular diseases and hypertension (Kamran *et al*., 2008). It was observed that the value of crude fibre tends to decrease with increased quantities of AYB flour. Fibre is needed to assist in digestion and keep the gastrointestinal tract healthy and can also help to keep the blood sugar stable. It slows down the release of glucose during digestion, so cells require less insulin to absorb that glucose (Agu *et al*., 2015).

The ash content of the control was 2.50%, that of corn flour (0:100) was the lowest (1.90%) while that of other samples that contained AYB flour were in the range of 2.55 to 4.85%. Sample containing only AYB flour had the highest value. The ash content decreased with increased quantity of corn flour in the formulation. The ash content indicates the mineral content of the formulated breakfast cereals. It is a non-organic compound that constitutes the mineral content of food. It aids in the metabolism of other compounds such as protein, fat and carbohydrate (Agu *et al*., 2015).

The quantity of carbohydrate in the control (74.96%) did not differ significantly from that of the sample with only corn flour (0:100). The carbohydrate content of the sample with only AYB flour was the least (37.90%). The carbohydrate contents of the samples with blends of AYB flour and corn flour were in the range of 57.61 to 63.55% and a gradual increase in the value of carbohydrate with increased addition of corn flour was observed.

The gross energy value of the control was 370.80 kCal/100g and it did not differ significantly (p>0.05) from that of samples with AYB-corn composite flour blends. This showed that the formulated breakfast cereals made from low cost composite flours were as good as the commercial Weetabix in terms of energy content. The lowest values of energy were found in samples with only AYB flour (100:0) and only corn flour (0:100).

Calcium and Potassium Composition

The results of calcium and potassium contents are presented in Table 3. The calcium content of the control was very low (100.08 mg/100g) compared to that of the formulated samples. This agrees with the result of proximate composition in which the control also had the least ash content. The formulated breakfast cereal with 30% AYB flour and 70% corn flour had calcium content of 339.37 mg/100g. The content of calcium in other formulated samples were very high (464.29 to 482.14 mg/100g). Thus, the formulated breakfast cereals have the capability of preventing osteoporosis and other calcium deficiency conditions than the commercial Weetabix.

The potassium content of the control was 15.84 mg/100g but in the formulated samples, they were in the range of 11.83 to 24.66 mg/100g. Apart from sample with only corn flour (0:100) whose potassium content was lower than the control, the potassium contents of the other samples were all higher than that of the control, the highest was found in Sample with only AYB flour (100:0) had the highest in the sample with only AYB flour (100:0). Significant difference existed in formulation with 60% AYB flour and 40% corn flour as well as in 50% AYB flour and 50% corn flour. Thus, these samples may provide more of the body’s potassium needs compare to the commercial Weetabix.

Table 3: Calcium and potassium contents of the breakfast cereal blends.

Sample (%AYB: %CF)	Ca (mg/100g)	K (mg/100g)
100:0	464.29[a]±0.85	24.66 [a] ±0.20
0:100	482.14 [a] ±0.48	11.83[d]±0.16
60:40	482.14 [a] ±0.70	20.66[b]±0.60
50:50	482.14 [a] ±0.70	19.15[b]±0.55
40:60	482.14 [a] ±0.89	17.36[bc]±0.09
30:70	339.37 [b] ±0.25	16.94[c]±0.03
Control	100.08 [c] ±0.37	15.84[c]±0.17

Values are means ±SD of triplicate determinations. Values with different superscripts along the same column are significantly different ($p>0.05$).
AYB= African Yam Bean Flour; CF= Corn Flour; Control= Weetabix

Sensory Properties
The result of the sensory evaluation is presented in Table 4. The mean scores for aroma ranged from 5.33 to 6.80 while that of appearance ranged from 5.00 to 6.93, the highest was found in the control. The mean scores for taste ranged from 3.46 to 8.06, the least was found in sample with only AYB flour while the highest was found in the control. The mean scores for texture ranged from 2.40 to 5.33. The least was found in sample with only AYB flour (100:0) while the highest was found in the composite flour blends containing of 50% AYB:50% corn flour and 40% AYB:60% corn flour. The value for overall acceptability ranged from 4.18 to 6.37. The highest value was found in the control. The overall acceptability value showed that the AYB flour and corn flour individually are not acceptable breakfast cereals since the samples with 100% AYB flour and that of 100% corn flour were all rejected by the judges while the composite AYB-corn flours breakfast cereal blends were all accepted.

Table 4: Mean sensory scores of breakfast cereal blends

Sample (%AYB:%CF)	Aroma	Appearance	Taste	Texture	Overall acceptability
100:0	6.80^{a}±1.32	5.00^{c} ±1.64	3.46^{c}±1.90	2.40^{c}±1.12	4.18^{c}
0:100	6.66^{a}±1.44	5.60^{b} ±1.88	4.66^{bc}±1.34	3.46^{b}±1.80	4.93^{bc}
60:40	5.33^{b}±2.05	5.20^{bc} ±1.69	4.66^{bc}±1.99	5.13^{a}±2.03	5.09^{b}
50:50	6.33^{a}±2.05	5.46^{b} ±1.12	5.00^{bc}±1.69	5.33^{a}±1.83	5.46^{b}
40:60	5.80^{ab}±2.07	5.73^{b} ±1.38	5.06^{bc}±1.53	5.33^{a}±1.83	5.37^{b}
30:70	6.13^{ab}±1.24	5.46^{b} ±1.72	5.40^{b}±1.72	4.93^{ab}±2.28	5.39^{b}
Control	5.66^{c}±2.19	6.93^{a}±1.79	8.06^{a}±1.09	4.93^{ab}±1.38	6.37^{a}

Values are means ±SD of triplicate determinations. Values with different superscripts

along the same column are significantly different ($p<0.05$).
AYB= African Yam Bean Flour; CF= Corn Flour; Control= Weetabix

Conclusions

African yam bean flour and corn flour separately are not acceptable for formulating breakfast cereal. Acceptable breakfast cereals with improved protein, fat, fibre, potassium and calcium contents and high energy content can be produced by the composite flour comprising of 50 % of African yam bean flour and 50 % corn flour. Commercialization of this novel product could also be beneficial to industries and can boost the economy of countries where these grains are grown.

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