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Nutrient Composition and Sensory Properties of Breakfast Cereal Made from Yellow Maize and Enriched with Soybean and Groundnut Flours

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A B S T R A C T

The aim of this study was to assess the nutrient composition and sensory properties of breakfast cereal made from yellow maize and enriched with soybean and groundnut flours. Yellow maize was replaced with groundnut (GF) (15–35%) and soybean flour (SBF) (10–15%) to produce a more nutritionally balanced breakfast cereal. Proximate, mineral, vitamin, and sensory analysis were carried out on the formulated breakfast cereals. The results showed that groundnut and soybean flour supplementation significantly increased the protein content (20.90–23.01%) as compared to the control along with an increase in fat (10.52-11.28%), crude fibre (2.98–3.90%), and ash (1.99–2.60%), while carbohydrate (57.09–52.66%) and energy (406.64–403.79 Kcal) decreased with the incremental addition of SBF and GF. Similarly, calcium (36.16-37.98 mg/100g), magnesium (32.16-37.98 mg/100g), potassium (10.62-12.16 mg/100g), iron (42.21-48.65 mg/100g) and vitamin A (70.07-74.01) g/dl) content of the breakfast cereals also increased significantly with increasing SBF and GF substitution, while a decrease was observed for phosphorus. The highest total score of sensory evaluation was for the control sample (golden morn), which was followed closely by the sample containing 20% GF and 15% SBF. Higher levels of SBF and GF can improve the nutritional value of breakfast cereals.

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Introduction

Breakfast cereals are foods made by swelling, crushing, rolling, or flaking any cereal (Sharma and Caralli, 2004). They are processed grain-based foods that are frequently consumed as the first meal of the day. Breakfast cereals, although being ingested dry in the early hours of the day, provide a good amount of strength, which is a crucial necessity for the human body. They are frequently eaten in conjunction with other foods to compensate for the deficits inherent in grains (Enwere and Ntuen, 2005). They are classified as classic hot cereals, which require additional heating or cooking before consumption, or ready-to-eat cereals, which are typically eaten with cream or milk (Emelike et al., 2020). Ready-to-eat cereals are growing in popularity in most developing countries and are eventually replacing most. Consumers today want an ever-expanding variety of more suitable light items that are low in calories and high in nutritional value. As a result, the idea of manufacturing low-cost breakfast cereal that offers essential nutrients to the body is critical.

Maize (*Zea mays* L.) is an annual crop of the poaceae grass family (Kuma and Jhariya, 2013). It is Nigeria's second most significant cereal crop, following sorghum, with an approximate yearly output of 5-6 million tonnes (Sule et al., 2014). It is also the world's third most important crop after rice and wheat (Sadhu et al., 2007). The maize grain includes 10.23 g moisture, 8.84 g protein, 4.57 g fat, 2.33 g ash, 2.15 g fiber, and 71.88 g carbohydrate per 100 g edible amount (Gopalan et al., 2007). It is a versatile crop that is utilized for both animal feed and human sustenance. It can be utilized as a raw ingredient to create a variety of foods, including flour, starch, breakfast cereals, snacks, and corn meal (Shah et al., 2016). The yellow maize type includes a lot of carotenoid pigments, which are good for preventing cancer (Michaud et al., 2000). Maize, a cereal crop, has a lower nutritional value than legumes. It is deficient in trace minerals, vital amino acids, and ascorbate (Barber et al., 2017). Complementation with protein-rich accompaniments such as legumes is required, resulting in protein nutritional compensation.

Cowpea (*Vigna unguiculata* (L.) Walp.) and soybeans (*Glycine max* (L.) Merr.) are good providers of calcium and iron, respectively, and contain significant quantities of minerals and vitamins (Barber et al., 2017). Soybeans are widely utilized because they have a higher nutritional content than other legume crops. Products derived from soybean protein have been employed as functional food components in nearly every food group available to consumers (Qin et al., 2022). Soybean seeds are high in protein, and their amino acid makeup is similar to that of animal proteins (Okwunodulu et al., 2020). They are a major source of plant-based proteins, with protein levels ranging from 36 to 56 percent by dry weight (Qin et al., 2022).

Peanut (*Arachis hypogaea* L.) is a legume that is commonly cultivated as a food crop. It is the world's sixth most significant oilseed crop, cultivated and produced in both tropical and temperate zones (Adegoke et al., 2014). The dry seed is rich in minerals (phosphorus, calcium, magnesium, and potassium), as well as vitamins E, K, and B-complex (Ayoola et al., 2012). Peanut is an excellent supply of protein with a high lysine content that complements yellow maize in the preparation of breakfast cereal. The nut has a variety of applications and can be utilized whole or processed to produce peanut butter, oil, soups, stews, and other items. The cake is also used in the preparation of animal and supplementary feeds. Peanuts can also be made into confectionary or snack foods (Amoniyan et al., 2020).

Breakfast cereals' nutritional quality has been improved via efforts. This includes, but is not limited to, fortifying breakfast cereals with legumes in enrichment methods (Emelike et al., 2020). Breakfast cereal intake is increasing, particularly among children, as people's eating habits change. When compared to the individual components, complementing maize with affordable stable legumes/pulses such as soybean and groundnut will help to enhance the nutritional quality of breakfast cereals prepared from maize. Hence, this study aimed to evaluate the nutrient composition and sensory properties of breakfast cereal made from yellow maize and enriched with soybean and groundnut flours.

Materials and Methods

Materials procurement

The soybeans (*G. max*), groundnut (*A. hypogea*) and yellow maize variety (*Z. mays*) were purchased from Itam market in Itu LGA, Akwa Ibom State, Nigeria. Chemicals and other reagents used in this research work were of analytical grade and were obtained from the Department of Food Science and Technology, University of Uyo, Uyo, Akwa Ibom State.

Preparation of Maize Flour

Maize flour was produced according to the method described by Barber et al. (2017), as shown in Figure 1. Five kilograms (5 kg) of yellow maize grains was sorted and further cleaned, winnowed, steeped to make the grains soft, and drained. The washed maize was dried in a hot air oven at 60°C overnight. The dried grains were dry-milled, sieved with 0.2 mm sieve, and stored in a well-labeled transparent plastic container until further use.

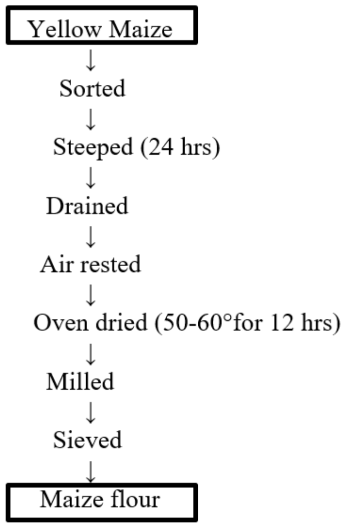

Figure 1. Flow chart for the production of Maize Flour
Source: (Barber et al., 2017)

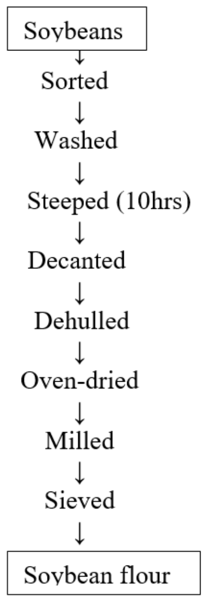

Figure 2. Flow chart for the Production of Soybean flour
Source: (Modified method of Nkwakalor and Obi, 2014)

Preparation of Soybeans Flour

Soybean flour was produced according to the method described by (Nkwakalor and Obi, 2014) with slight modification. The soybeans were sorted to remove extraneous materials. It was washed cleaned and steeped for 10 hours to make the soybean soft for further processing. The steeped soybeans were drained and pre-cooked for 15 minutes at 100°C after which it was dehulled (by rubbing between the palms) and the hulls were removed by rinsing with clean water. The dehulled soybeans were dried in the cabinet drier at 100°C for 5 hours and dry milled into fine flour. The soybean flour was further sieved to obtain smooth flour and packaged in a low density polyethylene bag until use.

Preparation of Groundnut Flour

The groundnut was cleaned by hand sorting and roasted for 2 hrs at 120°C, dehulled and milled. It was finally sieved to get fine flour.

Products Formulation

Composite flour was produced by mixing yellow maize, soybean and groundnut flour. Four different samples of breakfast cereal were formulated by mixing the three flour samples in different proportions of 70: 15:15; 65:20:15; 60:30:10 and 55:35:10 with sugar, salt and water (Table 1).

Breakfast Cereal Production

To each of the treatment, 2 portions of the formulation (170 g of the composite flour, 28 g of granulated sugar, 2 g of salt) and 200mL of deionized water were added before mixing to obtain the dough. The mixes were kneaded on a flat surface and passed through an extruder (model: MC-8830). The extruded dough was placed in an oven (NAAFCO BS Oven, model: OVH-102) at 110ºC for 1 hr until a dry extruded breakfast cereal was obtained. The products were allowed to cool and packaged in an air tight container (Emelike et al., 2020).

Proximate Analysis

The breakfast cereals' proximate composition (moisture, protein, carbohydrate, fat, crude fiber, and ash content) was measured using established procedures (AOAC, 2012). The moisture content was evaluated by drying 5 g of milled samples in an air oven at 130oC for 1 hour (NAAFCO BS Oven, model: OVH-102). For 24 hours, ash was measured gravimetrically in a muffle furnace (Sanyo Gallenkamp, Weiss Technik, West Midlands, UK) at 550oC. In a micro soxhlet extraction apparatus, 0.5 g of material was exhaustively extracted with petroleum ether (Gerhardt, Bonn, Germany). Protein was determined using the Kjeldahl method, which included distillation and titration with a factor of 5.7. Carbohydrate was calculated by subtracting moisture, protein, fat, crude fiber, and ash from 100 percent.

Mineral and Vitamin A Analysis

Mineral elements of the breakfast cereals were analyzed using an Atomic Absorption Spectrophotometer, AAS (Model 372, Perkin-Elmer, Beaconsfield, UK) according to the procedure described by AOAC (2012). Vitamin A was carried out as described by Onwuka (2005).

Sensory Analysis

The four formulated samples were served to 20 semi-trained panelists consisting of students of the University of Uyo, along with golden morn (Control) using a 9-point Hedonic scale (1=dislike extremely, 9=like extremely). The samples were served dry and assessed for appearance, taste, aftertaste, mouth feel, aroma, texture and overall acceptability. The panelists were made to analyze the samples independently to avoid expectation errors and other interferences (Iwe, 2007).

Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) and mean separation was done by Duncan multiple range test and Tukey's comparison test (p=0.05) using SPSS package version 23.

Results

Table 2 shows the proximate composition of breakfast cereals developed from blends of yellow maize, soybean and groundnut. Moisture content of the samples ranged from 6.52% in sample A (70% YM: 15% SBF: 15% GF) to 6.82% in sample C (60% YM: 30% SBF: 10% GF). Fat content of the samples were 10.52%, 10.65%, 11.08%, and 11.28% for samples A, B, C and D, respectively. Protein content was highest in sample D with a value of 22.90% while sample A had the lowest value (20.90%). Ash content of the samples ranged from 1.99% to 2.60% with sample A having the lowest (1.99%) while sample D had the highest value (2.60%). Crude fibre content ranged from 2.98% in sample A to 3.90% in sample D. Carbohydrate content recorded 57.09%, 56.03%, 53.10% and 52.66%, for samples A, B, C, and D, respectively with sample A having the highest value while sample D had the lowest. Energy content ranged from 403.79 Kcal in sample D to 406.64 Kcal in sample A.

Table 1. Formulations for Breakfast Cereals from flour blends of yellow maize, groundnut and soybean

Ingredients	A	B	C	D
Yellow maize flour (%)	70	65	60	55
Groundnut flour (%)	15	20	30	35
Soybean flour (%)	15	15	10	10
Sugar (g)	28	28	28	28
Salt (g)	2	2	2	2

Source: (Author's Computation)

Table 2. Proximate composition of breakfast cereals developed from blends of yellow maize, soybean and groundnut

Samples	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)	Energy (Kcal)
A	6.52 ± 0.02^{c}	10.52 ± 0.20^{c}	20.90 ± 0.05^{d}	1.99 ± 0.01^{d}	2.98 ± 0.02^{d}	57.09 ± 0.01^{a}	406.64 ± 0.04^{a}
B	6.56 ± 0.04^{c}	10.65 ± 0.02^{c}	21.25 ± 0.02^{c}	2.20 ± 0.02^{c}	3.31 ± 0.02^{c}	56.03 ± 0.03^{b}	404.97 ± 0.03^{b}
C	6.82 ± 0.02^{a}	11.08 ± 0.02^{c}	23.01 ± 0.01^{a}	2.40 ± 0.04^{b}	3.59 ± 0.01^{b}	53.10 ± 0.05^{c}	404.16 ± 0.04^{c}
D	6.66 ± 0.04^{b}	11.28 ± 0.04^{a}	22.90 ± 0.05^{b}	2.60 ± 0.04^{a}	3.90 ± 0.05^{a}	52.66 ± 0.03^{d}	403.79 ± 0.03^{d}

A= 70% YM: 15% SBF: 15% GF; B= 65% YM: 20% SBF: 15% GF; C= 60% YM: 30% SBF: 10% GF; D= 55% YM: 35% SBF: 10% GF; YM= Yellow maize; SBF= Soybean flour; G= Groundnut flour; Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at (P<0.05).

Table 3. Mineral and vitamin A composition of breakfast cereals from blends of yellow maize, soybean, and groundnut

Samples	P (mg/100g	Ca (mg/100g)	Mg (mg/100g	K (mg/100g)	Fe (mg/100g)	Vitamin A (µg/dl)
A	70.80±0.05^{a}	36.22±0.02^{d}	32.16±0.02^{c}	10.62±0.02^{d}	42.21±0.01^{d}	70.07±0.03^{d}
B	62.18±0.02^{b}	40.25±0.05^{c}	36.00±0.02^{b}	10.82±0.02^{c}	47.27±0.03^{c}	71.07±0.05^{c}
C	52.16±0.04^{c}	40.90±0.05^{b}	36.01±0.01^{b}	10.90±0.05^{b}	47.82±0.02^{b}	73.05±0.05^{b}
D	46.46±0.03^{d}	42.16±0.03^{a}	37.98±0.02^{a}	12.16±0.01^{a}	48.65±0.05^{a}	74.01±0.01^{a}

A= 70% YM: 15% SBF: 15% GF; B= 65% YM: 20% SBF: 15% GF; C= 60% YM: 30% SBF: 10% GF; D= 55% YM: 35% SBF: 10% GF; YM= Yellow maize; SBF= Soybean flour; G= Groundnut flour; Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at (P<0.05).

Table 4. Mean Sensory Scores for Breakfast Cereals from Blends of Yellow maize, Soybean and Groundnut Served Dry

Samples	Appearance	Taste	Mouth feel	After taste	Aroma	Texture	Overall Acceptance
A	8.06±1.09^{a}	8.46±0.63^{a}	8.20±0.86^{a}	8.26±0.70^{a}	8.20±1.04^{a}	7.66±1.34^{a}	8.40±0.73^{a}
B	6.80±1.47^{b}	6.46±1.12^{b}	6.33±1.29^{b}	6.20±1.20^{b}	6.46±1.64^{b}	6.06±1.70^{b}	6.53±1.50^{b}
C	7.28±1.03^{ab}	7.00±0.92^{b}	6.53±0.99^{b}	6.60±1.35^{b}	6.60±1.12^{b}	6.06±1.38^{b}	7.00±1.41^{b}
D	7.06±1.43^{b}	6.53±1.35^{b}	6.53±1.72^{b}	6.66±1.49^{b}	6.80±0.86^{b}	6.26±1.09^{b}	6.86±1.18^{b}
E	6.80±0.86^{b}	6.26±1.16^{b}	6.33±1.04^{b}	6.33±1.49^{b}	6.53±1.06^{b}	6.60±0.98^{b}	6.73±0.79^{b}

A= Control (Golden morn); B= 70% YM: 15% SBF: 15% GF; C= 65% YM: 20% SBF: 15% GF; D= 60% YM: 30% SBF: 10% GF; E= 55% YM: 35% SBF: 10% GF; YM= Yellow maize; SBF= Soybean flour; G= Groundnut flour;
Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at (P<0.05).

Table 3 shows the mineral and vitamin A composition of breakfast cereals developed from blends of yellow maize, soybean and groundnut. Phosphorus content ranged from 46.46 mg/100g in sample D to 70.80 mg/100g in sample A. Calcium and magnesium contents ranged from 36.22-42.16 mg/100g and 32.16-37.98 mg/100g, respectively with sample A having the lowest value while sample D had the highest. Potassium content was highest (12.16 mg/100g) in sample D and lowest (10.62 mg/100g) in sample A. Iron content ranged from 42.21-48.65 mg/100g with the lowest value found in sample A while sample D had the highest. Vitamin A content was highest (74.01 µg/dl) in sample D and lowest in sample A (70.07 µg/dL).

Table 4 shows the sensory properties of breakfast cereals developed from blends of yellow maize, soybean and groundnut. Appearance scores ranged from 6.80 in samples B and E to 8.06 in sample A (control sample). Sample A was most preferred for taste while sample E was least preferred with scores ranging from 6.26-8.46. Mouth feel ranged from 6.33 in samples B and E to 8.20 in sample A. After taste and aroma of the samples ranged from 6.20-8.26 and 6.46-8.20 with the lowest scores found in sample B while sample A had the highest. Sample B had the lowest texture and overall acceptability scores while sample A had the highest with scores ranging from 6.06-7.66 and 6.53-8.40, respectively.

Discussion

The formulated breakfast cereals had low moisture content in general, implying that they might have a longer shelf life in their natural state. According to Ayo-Omogie and Odekunle (2015), bakery products with a moisture content of less than 13% are resistant to moisture-dependent degradation. The moisture content of the formulated breakfast cereals was less than the required moisture content. The ash level of the samples reduced as groundnut and soybean supplementation increased. The ash level of any food material is an indicator of the food's non-organic component, comprising mineral content. The sample enriched with 35% SBF and 10% GF had the highest ash content, implying that the formulated sample can be used to improve the mineral levels of consumers. The value for ash obtained is comparable to the values of 1.05-2.40% reported by Usman et al. (2015).

The increase in the fat content of the breakfast cereals upon substitution with SBF and GF is expected as soybean and groundnut are rich sources of fat. This increase was equally reported by Emelike et al. (2020). Because fat plays an important role in forecasting the shelf-life of food products, a high fat content in baked goods may be undesirable because it increases rancidity, which leads to the formation of unpleasant and odorous substances (China et al., 2020). The increase in protein content of the samples might be attributable to the addition of soybean and groundnut flour, indicating that soybean and groundnut are better protein sources than maize. A similar finding was also reported by Agu et al. (2015) for malted acha-soy breakfast cereal. The value obtained from this study is similar to the values of 21.3-23.9% reported by Eke-Ejiofor and Okoye (2018). This suggests that the protein content of the formulated breakfast cereals will be enough. As a result, consuming it will allow the body to obtain a sufficient quantity of protein, which will improve day-to-day functions of the body structure and may also aid in the prevention of protein-energy malnutrition, which is common in developed countries.

The increase in crude fibre of the breakfast cereals observed in this study upon substitution with soybean and groundnut is in line with the findings of Emelike et al. (2020), who reported an increase in the fibre content upon substitution with cashew kernel. The value obtained from this study is similar to the value of 1.60% reported by Randeniya et al. (2016) for ovalbumin-incorporated breakfast cereal. The high fibre content of the formulated breakfast cereals suggests that these products will aid digestion, thereby preventing constipation (Elleuch et al., 2011). The decrease in the carbohydrate content of the complementary foods could be principally due to the low carbohydrate content of soybean and groundnut flour over maize. A similar decrease was also reported by Emelike et al. (2020). The values obtained in this study were higher than the values of 36.6-4.40 reported by Eke-Ejiofor and Okoye (2018). Carbohydrate levels in all formulated breakfast cereals are nutritionally acceptable, as children need energy to perform their vigorous playing and other tasks as they grow. The observed variations in the energy values of the formulations could be attributable to variances in the samples' protein, fat, and carbohydrate contents. The results obtained in this study are lower than the values of 452.6–505.0 Kcal reported by Eke-Ejiofor and Okoye (2018) for breakfast cereals produced from different cereal grains. The low energy content could be attributed to the supplementation with soybean and groundnut flour.

The significant difference in the mineral elements observed from this study could be attributed to the variation in the composite flour formulation. Phosphorus was the most abundant mineral in all the breakfast cereals and was followed by iron. Phosphorus intake in breakfast cereals is necessary since phosphorus is an essential component of all living cells. It is also needed for the development of the bones. Adequate iron in breakfast cereals is also necessary to reduce the occurrence of iron deficiency anemia, which is the most frequent nutritional condition globally (Short and Domgalski, 2013). The increase in the mineral composition (calcium, magnesium, potassium, and iron) observed in this study could be attributed to the supplementation of yellow maize with soybean and groundnut. Similar findings were also reported by Edima-Nyah et al. (2019) for breakfast cereal supplemented with soybean and unripe banana. According to Ascherio et al. (1992), legumes such as soybeans are rich in fiber, iron, potassium, magnesium, and fiber, which have a positive impact on blood pressure management.

The high content of vitamin A obtained for the breakfast cereals from this study is due to the use of yellow maize. Muzhingi et al. (2011) reported that yellow maize is an effective source of vitamin A and can provide 40–50% of the adult vitamin A Recommended Dietary Allowance. The increase in the vitamin A content of the breakfast cereals could also be due to supplementation with SBF and GF. The value obtained from this study is higher than the values of 12.30–22.01 g/dl reported by Edima-Nyah et al. (2019). Mbaeyi-Nwaoha and Uchendu (2016) also reported values of 11.13–83.05 g/dl for breakfast cereal made from acha and fermented soybean paste, which is close to the values obtained from this study. Vitamin A is necessary because it aids in vision, bone formation, and immune system regulation, which aids in the defense against infections by generating white blood cells that eliminate pathogenic germs and viruses (Ikeme-Emanuel et al., 2012).

In this study, the control sample was most preferred for all sensory attributes. The mean scores of the breakfast cereals also decreased significantly as the supplementation with soybean and groundnut flour increased. Appearance and taste are important sensory attributes that affect the acceptability of food products. Among the formulated breakfast cereals, these parameters were higher in samples enriched with 20-30% soybean and 10-15% groundnut flour. The overall acceptability of the control sample was also significantly higher than the formulated breakfast cereals. This could be attributed to the supplementation with soybean and groundnut flour which may have altered the sensory attributes of the breakfast cereals. Despite the decrease, the formulated breakfast cereals were above the average 6.0 which implies that the samples were still preferred by the panelists, however, the sample enriched with 20% soybean and 15% groundnut flour had the highest overall acceptability. This is consistent with the findings of Mbaeyi-Nwaoha and Uchendu (2016), who stated that the panelists approved of the sensory quality of breakfast cereals, made with acha and fermented soybean paste mixtures. This implies that breakfast cereals can be formulated from the blends of yellow maize/soybean/groundnut at the ratios of 65:20:15, respectively without significantly altering the sensory characteristics of the product.

Conclusion

The results of this study showed that the supplementation of yellow maize with soybean and groundnut flour at higher levels significantly improved the nutritional composition in terms of protein, fat, crude fibre, calcium, magnesium, potassium, iron, and vitamin A content while reducing the saponin and phytate content of the samples. However, a good quality and acceptable breakfast cereal can be prepared by substituting yellow maize with 15% soybean flour and 25% groundnut.

Conflict of Interest

No potential conflict of interest relevant to this study was reported.

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