Proximate, Minerals and Sensory Evaluation of Breakfast Cereal made from Acha enriched with Soybeans and Sesame Seed flour

Abstract

Breakfast cereal is a major morning meal and it is a source of nutrients for both children and adults. Therefore, this study aimed at evaluating the proximate analysis, mineral and sensory evaluation of breakfast cereal made from acha enriched with soybean and sesame seed flour. Raw materials used for this study were purchased from Ojakoko in Owo Local Government, Ondo State. Four composite blends were formulated into ratio; sample A (70% Acha; 20% soybean; 10% sesame seed), sample B (60% Acha; 25% soybean; 15% sesame seed), sample C (50% Acha; 25% soybean; 25% sesame seed) and sample D (40% Acha; 40% soybean; 20% sesame seed). Standard procedures were used to determine the proximate and minerals composition while sensory properties were determined using 9 point hedonic scale. Data generated were statistically analyzed using analysis of variance to test for the significant difference among means ($P<0.05$) using Statistical Package for Social Science (SPSS version 25). Finding shows that the sample B (12.26%) was significantly ($P<0.05$) higher in moisture content compared to other samples. Sample A was significantly ($P<0.05$) high in protein (26.94%), fat (21.09%) and Ash (3.82%). Crude fibre was significantly ($P<0.05$) high in sample C (6.25%) while sample A (41.91%) was significantly ($P<0.05$) high in carbohydrate. Mineral analysis shows that the sample A significantly ($P<0.05$) had the highest value for sodium (114.55ppm), calcium (161.40ppm), potassium (711.25ppm), magnesium (17.55ppm), iron (3.19ppm) and phosphorus (71.51ppm) while sample D had the least Ca (135.50ppm), Mg (10.92ppm) and P (62.63ppm). Results on sensory evaluation shows that sample D had the highest values in terms of flavour (5.70), aroma (5.25), appearance (5.10), taste (4.60) and colour (5.60). In conclusion, the Acha enriched breakfast cereal had an appreciable amount of nutrients and sensory attribute but sample A had the most promising nutrient composition including minerals content while sample D had the most acceptable organoleptic quality and can improve the nutritional status of the consumer.

Keywords: Acha, Sesame seed, Proximate, Minerals, Sensory attributes,

INTRODUCTION

Breakfast can be simply refers to the act of ending the overnight fast, typically lasting 10-12 hours [1]. As the most crucial meal of the day, breakfast plays a vital role in kick-starting our metabolism. Nutritionists widely acknowledge its importance, citing the efficient utilization of food consumed during breakfast compared to other meals [1]. Research underscores the significance of protein in breakfast, with high-protein meals outperforming low-protein ones in terms of benefits. This protein intake helps regulate blood sugar levels between mid-morning and lunch [2). Breakfast primarily consists of cereals, which are the edible seeds of grass family plants cultivated for their grains. These plants are the most consumed globally. Cereals are inherently low in fat and rich in essential nutrients, including zinc, phosphorus, calcium, iron, B-

vitamins, and other vital minerals [1]. Beyond providing crucial vitamins and minerals, cereals offer the added benefits of whole grains.

Breakfast cereals, encompassing ready-to-eat options, oats, porridge, and muesli, serve as primary sources of morning carbohydrates. These cereals come in diverse formulations and have been linked to reduced risks of chronic diseases in adults and adolescents. Developing optimal breakfast cereals involves combining raw materials to achieve specific nutritional profiles. Beyond carbohydrates, breakfast cereals provide essential micronutrients and fiber, including β-glucans, which help prevent cardiovascular issues, control appetite, and increase satiety.

“Acha (D*igitariaexilis*and *Digitariaiburua*) is an ancient West African cereal crop cultivated for its straw and edible grains. It is believed to be Africa’s oldest cereal. Acha grains are extensively grown in Nigeria’s cooler regions, including Plateau State and parts of Bauchi, Kebbi, Taraba, Kaduna, and Niger States. Locally, it is known by various names, such as hungry rice, fonio, fundi, pom, and kunbug. Among its varieties, white Acha*(Digitariaexilis)* dominates Nigerian cultivation, whereas black Acha (*Digitariaiburua)* is rarely grown. Despite its significance, Acha has been largely overlooked, earning the label lost crop of Africa. Compared to sorghum, pearl millet, and maize, Acha has received minimal attention, underscoring its untapped potential in rural economies and food supply enhancement” [6].

“Sesame seed is considered to be the oldest oilseed crop known to humanity”[7]. The genus has many species, and most are wild. Most wild species of the genus Sesamum are native to sub-Saharan Africa. S. Indicum, the cultivated type, [8] originated in India [9]. Demonstrating adaptability, sesame thrives in various soil types, optimally in well-drained, fertile soils with medium texture and neutral pH, but exhibits low tolerance for high salt and waterlogged conditions. To flourish commercially, sesame requires 90 to 120 frost-free days and warm temperatures above 23°C. Although it can grow in poor soils, optimal yields are achieved through proper fertilization (10).Study had reported the sesame seeds to contain 45-55% oil, 19-25% protein and about 5% water. The seeds were also reported to contain 25 percent protein, which are rich in methionine and tryptophan, and one ounce of decorticated or hulled seeds contains 6 grams of protein, 3.7 grams of fibre, and 14 grams of total fat [11].

“Sesame seeds contain a beneficial fatty acid profile, consisting of 38% monounsaturated and 44% polyunsaturated fats. The oil extracted from sesame seeds is high-quality, odorless, and resistant to spoilage due to its antioxidant properties, which also offer anti-carcinogenic and

cholesterol-lowering benefits. Additionally, sesame oil protects the liver from damage and is rich in oleic and linoleic acids (40% each), with a relatively low saturated fat content (14%). This nutritional profile makes sesame seed flour an ideal ingredient for enhancing the nutritional value of breakfast cereals, as explored in a study focusing on Acha-based cereals enriched with sesame seeds contain a beneficial fatty acid profile, consisting of 38% monounsaturated and 44% polyunsaturated fats" [12]. The oil extracted from sesame seeds is high-quality, odourless, and resistant to spoilage due to its antioxidant properties, which also offer anti-carcinogenic and cholesterol-lowering benefits [13]. Additionally, sesame oil protects the liver from damage and is rich in oleic and linoleic acids (40% each), with a relatively low saturated fat content (14%) [13] This nutritional profile makes sesame seed flour an ideal ingredient for enhancing the nutritional value of breakfast cereals, therefore, this study explored the formulation and evaluate proximate, mineral and sensory attributes of breakfast cereals made from Acha enriched with soybean and sesame seed flour.

METHODOLOGY

Source of Materials

Acha, soybean and sesame seed used for this study were obtained from Oja Koko in Owo Local Government Ondo State, Nigeria

Source of Equipment

All equipment was obtained from the departmental store; this equipment includes Pots, Stoves, Knives, Blender, Spoons, and grater.

Sample Preparation

Preparation of Acha flour

This study adopted the method outlined in [14] to produce Acha flour. Initially, Acha grains were manually cleaned and sorted by hand-picking chaff. Subsequent washing in tap water using plastic bowls removed dust and sand. The grains were then oven-dried at 50°C for 6 hours. Following drying, the grains were finely milled into flour using an attrition mill and sieved to eliminate coarse and fibrous materials. The resulting flour was stored in airtight polythene bags at room temperature (25°C) until required.

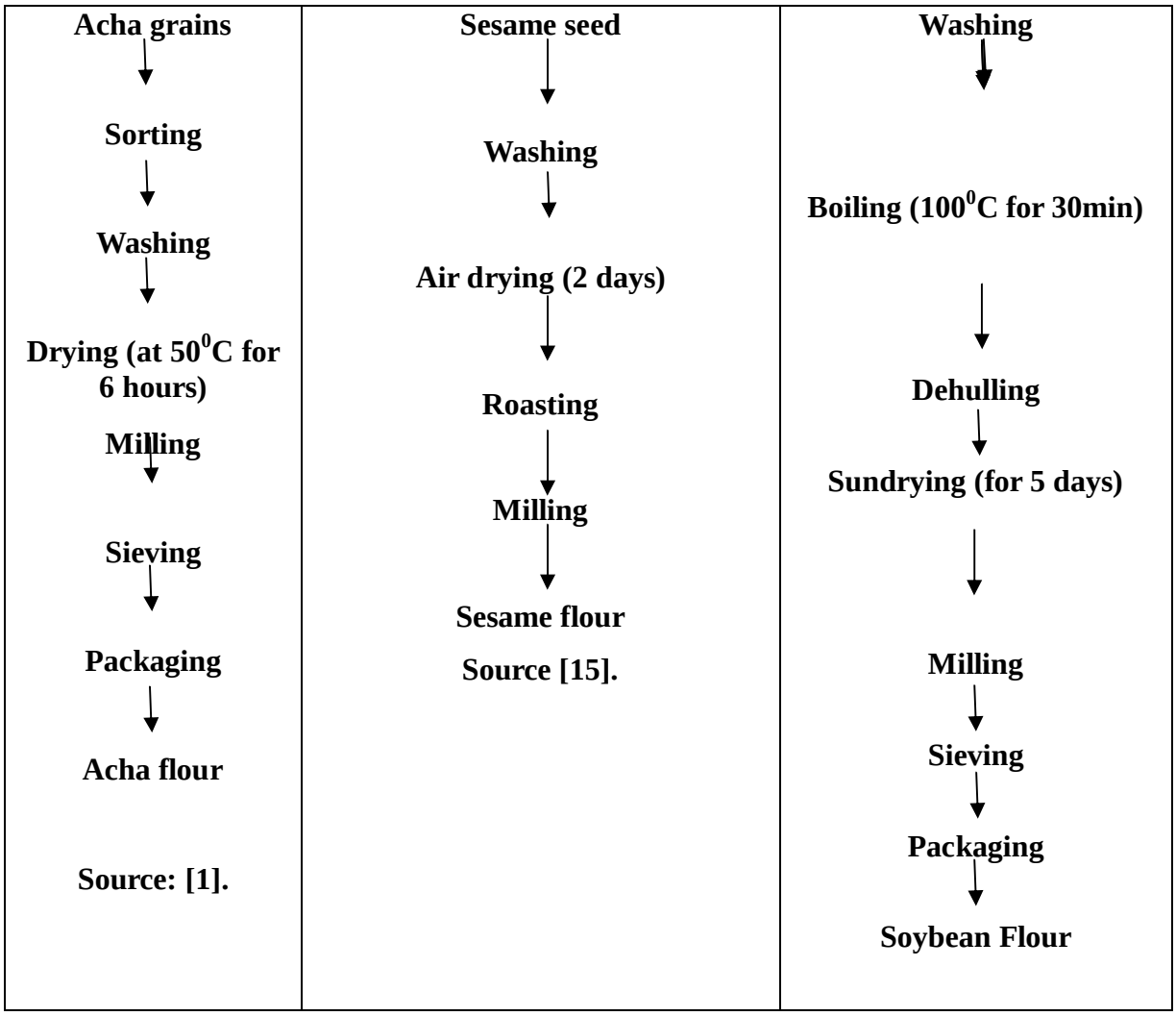

Figure 1: Modified flow diagram for the processing of the grains into Flour

Preparation of Soybean flour

This was produce according to the methods of[14]. Soybean was cleaned and sorted, washed and boiled in water at 100oC for 30 min. It was dehulled manually, sundried for five days. It was milled into flour using attrition mill and sieved to remove coarse material. The resultant fine flour was packaged in polythene bags and stored in air-tight container for further use.

Preparation of Sesame flour

This was produce according to the methods of [15].Sesame seed was washed with clean water to remove unwanted particles, rubbed in between the palms to remove testa, and then it was washed again several times before air drying for two days. It was then roasted at 70oC for 10 minutes. It was milled to smooth homogenous powder and packaged into airtight containers until required

Preparation of Breakfast

Based on preliminary preparations, about 3 to 4 tablespoons of the composite breakfast flour was pasted with 200 ml of clean tap water. Boiled water of about 300 ml was added with initial vigorous stirring followed by intermittent stirring for about 4 min, to obtain a desirable consistency. It was allowed to cool under room temperature and packaged in rigid plastic containers for analysis.

Determination of Proximate composition

Standard laboratory procedures of Association of Analytical Chemist (16) was used to analyze the samples: The proximate analysis was carried out according to AOAC methods [16], to determine moisture, crude fats, ash, crude protein, and crude fibre

Carbohydrate Content Determination

The carbohydrate content was determined by difference. The percentage total carbohydrate was estimated to be equal to the sum of percentage moisture, protein, ash and fibre subtracted from 100g. %carbohydrate= 100-(%protein+% fat+%ash+%moisture)

Procedure for Mineral Analysis

Calcium (Ca), sodium (Na) Magnesium (Mg), iron (Fe), zinc (Zn), selenium (Se) and potassium (k) content of each sample was estimated using the method of AOAC (2000). Two grams of each sample was ashes in muffle furnace at 550oC for 6 to 8 hours. “The ash was dissolved with HCl. The analysis of sodium, calcium, potassium, iron, magnesium, selenium and zinc was carried out with a Buck Model 210 VGP atomic absorption spectrometer, USA. In all cases, air-acetylene flame was used and a hollow cathode individual metal was the resonance line source. The calibration plot method was adopted for the analysis. For each element, the instrument was auto zeroed using the blank (de-ionized water) after which the standard was aspirated into the flame starting from the lowest concentration. The corresponding absorbance values were obtained and the graph of absorbance against concentration was plotted by the instrument. The digested samples was analyzed in duplicates with the average concentration of the metal present being displayed in part per million (ppm) by the instrument after extrapolation from the standard curve” (17,38).

Sensory Evaluation

The sensory attributes, including flavour, Aroma, taste, appearance, colour and general acceptability of the samples produced were evaluated by a semi-trained 20-member, using 9-points hedonic scale with 1 representing the least score(dislike extremely) and 9 the highest score (like extremely).

Statistical Analysis

The results were expressed as mean ± standard deviation and the test for statistical significance was carried out using one-way analysis of variance (ANOVA). The Statistical Package for Social

Sciences (SPSS, Version 20) software was used to determine significant differences. Significant means was separated using Duncan's New Multiple Range Test (DNMRT) and differences was considered significant at $p<0.05$

RESULTS

Proximate composition of the formulated breakfast cereal

Finding shows that the sample B (12.26%) was significantly ($P<0.05$) higher in moisture content compared to other samples. Sample D was significantly ($P<0.05$) high in Ash (3.82%). Crude fibre was significantly ($P<0.05$) high in sample C (6.25%) while sample A (41.91%) was significantly ($P<0.05$) high in carbohydrate. For the fat content, sample D had the highest value of 21.09% while sample B had the lowest value of 11.81%. Crude fibre content shows that sample C had the highest value of 6.25% while sample A had the lowest value of 5.74%. Sample D was significantly ($P<0.05$) high in protein (26.94%), while sample A had the lowest value of 22.09%. For the carbohydrate content, sample A contains higher value of 41.91% while sample B, C and D contained 38.73%, 35.09% and 36.18% respectively.

Table 1: Proximate composition of the formulated breakfast cereal

Samples (%)	Moisture	Ash	Fat	Crude fibre	Protein	Carbohydrate
A	11.50 ± 0.04^{a}	3.81 ± 0.02^{a}	13.25 ± 0.08^{c}	5.74 ± 0.09^{d}	22.09 ± 0.04^{d}	41.91 ± 0.01^{a}
B	12.26 ± 0.02^{a}	3.53 ± 0.02^{c}	11.81 ± 0.03^{d}	5.92 ± 0.06^{b}	24.51 ± 0.01^{c}	38.73 ± 0.02^{b}
C	12.16 ± 0.01^{b}	3.71 ± 0.05^{b}	16.93 ± 0.04^{b}	6.25 ± 0.04^{a}	25.83 ± 0.02^{b}	35.09 ± 0.01^{d}
D	10.98 ± 0.04^{d}	3.82 ± 0.05^{a}	21.09 ± 0.04^{a}	5.82 ± 0.03^{c}	26.94 ± 0.01^{a}	36.18 ± 0.02^{c}

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same columns are statistically not significant at ($P<0.05$).

Mineral composition of the formulated breakfast cereal

Table 2 shows mineral analysis shows that the sample A significantly ($P<0.05$) had the highest value for sodium (114.55ppm), calcium (161.40ppm), potassium (711.25ppm), magnesium (17.55ppm), iron (3.19ppm) and phosphorus (71.51ppm) while sample D had the least value for Ca (135.50ppm), Mg (10.92ppm) and P (62.63ppm), while sample C had the lowest potassium content. Sample B had the lowest value of 1.51ppm. Sample B contains the lowest value (2.78ppm) of iron.

Table 2: Mineral composition of the formulated breakfast cereal

Mineral (100g/ppm)	A	B	C	D
Sodium	114.55±0.21[a]	105.85±0.07[b]	101.55±0.35[d]	102.75±0.45[c]
Calcium	161.40±0.14[a]	147.30±0.14[c]	155.75±0.21[b]	135.50±0.00[d]
Potassium	711.25±0.07[a]	645.75±0.21[c]	638.35±0.21[d]	695.75±0.07[b]
Zinc	1.95±0.04[a]	1.51±0.04[d]	1.66±0.01[c]	1.73±0.02[b]
Magnesium	17.55±0.02[a]	13.74±0.01[c]	16.52±0.04[b]	10.92±0.01[d]
Iron	3.19±0.01[a]	2.78±0.01[c]	2.38±0.03[d]	2.81±0.04[b]
Phosphorus	71.51±0.02[a]	65.26±0.04[c]	66.96±0.04[b]	62.63±0.03[d]

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same columns are statistically not significant at (P<0.05).

Sensory Evaluation of the formulated breakfast cereal

Table 3 shows the sensory evaluation of formulated breakfast cereal from acha enriched with soybean and sesame seed flour. Sample D had the highest values in terms of flavour (5.70) while sample B had the lowest texture (3.60) with significant difference (p<0.05). In terms of aroma sample A had the least value of 3.60 while sample D had the highest value of 5.25. Sample D had the highest value for appearance (5.10) while sample C had the least value of 3.65. Sample D had the highest value of 4.60 in terms of taste with significant difference (p<0.05) among the samples The result for colour shows that sample D had the highest value (5.60) while sample A had the least value (4.35). Overall acceptability shows that sample D had the highest value of 6.50 while sample A had the least value of 4.80.

Table 3 Sensory Evaluation of the formulated breakfast cereal

Samples	Flavour	Aroma	Appearance	Taste	Colour	Overall Acceptability
A	5.36±1.18[b]	3.60±1.72[d]	3.95±2.11[c]	3.85±1.56[d]	4.35±1.66[d]	4.80±1.64[d]
B	3.60±1.31[d]	5.15±1.63[b]	4.30±1.59[b]	4.20±2.33[b]	5.20±2.23[b]	4.95±2.35[c]
C	4.80±1.43[c]	4.35±1.69[c]	3.65±1.46[d]	4.15±2.27[c]	4.40±1.98[c]	5.15±2.03[b]
D	5.70±1.62[a]	5.25±1.51[a]	5.10±1.80[a]	4.60±2.06[a]	5.60±2.39[a]	6.50±1.23[a]

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same columns are statistically not significant at (P<0.05).

DISCUSSION

The study's moisture content (ranging from 11.81% to 12.26%) exceeded previous reports (5.05-9.35%) for Acha-soy breakfast gruel [16]. Sample D's lower moisture content may be attributed to its higher protein content, courtesy of soybean, which binds moisture more effectively than carbohydrates [17]. This reduction enhances the product's shelf life and keeping quality by minimizing microbial growth. Ash content varied from 3.53% (Sample B) to 3.82% (Sample D), surpassing previous values (1.41-2.06%) for breakfast cereals made from Acha and fermented soybean paste [1]. The increase in ash content correlates with the higher mineral content of Acha grain and soy [18]. Ash content indicates the presence of mineral matter, essential for metabolizing macronutrients like protein, fat, and carbohydrates [19].

Fat content ranged from 11.81% to 21.09%, exceeding previous reports (1.89-10.23%) for breakfast cereals from fermented Acha, roasted soybean, and carrot [20]. Sample D had the highest fat content, while Sample B had the lowest. The significant increase in fat content with added soybean underscores the product's high energy value, attributed to soybean's oil-rich composition [14]. This aligns with energy requirements computed in previous studies [21, 22].

The crude fibre content of the samples ranged from 5.74% to 6.25%, exceeding previous values (1.87-2.72%) for breakfast cereals made from germinated spring grain flakes [4]. "Sample C had the highest value, while Sample A had the lowest. The high crude fibre content in samples with increased sesame seed is attributed to sesame's whole grains being rich in dietary fibre, beneficial for preventing constipation, cardiovascular diseases, and hypertension" [23]. "Sesame seeds bioactive components, including dietary fibre and Phytochemical, contribute to its recognized health benefits" [24]. Protein content varied from 22.09% to 26.94%, with Sample D having the highest value and Sample A the lowest. Although lower than previous reports (6.92-19.60%) [16], the protein content increased significantly ($p<0.05$) with soybean addition. This correlation is attributed to soybean's high fat content, consistent with [25]. Notably, Sample D's protein content (26.94%) aligns with FAO's reported value [22], confirming the nutritional value of the formulated breakfast cereal.The carbohydrate content of the samples varied from 35.09% to 41.91%, notably lower than previous reports (59.48-77.28%) [16]. "Whole meal Acha flour contained the highest carbohydrate percentage (41.91%). This substantial carbohydrate content makes whole meal Acha an excellent dietary complement for diabetic individuals, due to its low glycemic index" [26]. "Whole grain Acha is rich in fermentable carbohydrates that benefit gut

health.Moreover, whole grain breakfast cereals, like Acha, have been shown to be more effective prebiotics than wheat bran, increasing beneficial bifidobacteria and lactobacilli in humans" [27].

Minerals content

Sodium content ranged from 101.55ppm to 114.55ppm, significantly lower than previous reports (600.86-701.35ppm) for breakfast cereals made from Pearl Millet, Irish Potato, and Sesame Seed Blend [28]. Sample A had the highest value, while Sample C had the lowest. The low sodium content is attributed to minimal salt addition during preparation.The formulated breakfast cereals' low sodium content makes them suitable for adults, as diets low in sodium can reduce the risk of high blood pressure and stroke [29].Calcium content varied from 135.50ppm to 161.40ppm, with Sample A having the highest value and Sample D the lowest. Although lower than previous reports (1.97-3.23ppm) [1], these values meet the Recommended Dietary Allowance (RDA) for calcium (100ppm). The formulated samples provide 15.6-18.4% of the RDA.

As calcium deficiency is prevalent [30], the formulated breakfast cereals, rich in calcium, are an ideal meal option for both children and adults.The potassium content of the breakfast cereals ranged from 638.75 to 711.25ppm, significantly higher than previous reports (70.62-78.53ppm) for maize-jackfruit seed flour blends [31]. Sample A had the highest value, while Sample C had the lowest. Notably, potassium content decreased with increasing Acha flour in the formulation.Although lower than values reported for AYB-maize-defatted coconut flour breakfast cereals (88.00-191.00ppm) [32], the potassium content exceeded the US Recommended Dietary Allowance (RDA) for both men and women (3.5mg/100g).Potassium, primarily an intracellular cation, plays a crucial role in maintaining osmotic pressure regulating pH equilibrium, binding to proteins. These findings highlight the nutritional value of the formulated breakfast cereals, providing essential potassium.The formulated breakfast cereal samples contained zinc within the range of 1.51-1.95ppm, with Sample A having the highest value and Sample B the lowest. The results showed a decrease in zinc content with increasing soybean flour compared to other studies. Higher values were observed for a breakfast cereal sample made from soybean and sesame seed (1.73ppm). Lower values of 1.54- 1.64ppm, were also recorded for fortified breakfast cereal reported [34]. Zinc is a vital nutrient and plays a role in hundreds of bodily functions, from assisting in enzyme reaction to blood clotting and it's essential for taste, vision and wound healing [35].The formulated breakfast cereals provide a

notable amount of zinc, supporting various bodily functions [35].The formulated breakfast cereals contained magnesium within the range of 10.92-17.55ppm, with significant differences ($P < 0.05$) among samples. Sample A had the highest value, while Sample D had the lowest.Although lower than previous reports (290.02-430.01mg/100g) for AYB-maize-defatted coconut flour breakfast cereals [36], the magnesium content is still notable.Magnesium plays crucial roles in activation of many enzyme systems and maintains the electrical potential in the nerves [33]. Magnesium works with calcium to assist in muscle contraction, blood clotting and the regulation of blood pressure and lung function [37].The breakfast cereals, rich in magnesium, make an ideal meal option for both men and women.The formulated breakfast cereals contained iron within the range of 2.38-3.19ppm, with Sample A having the highest value and Sample D the lowest. Significant differences ($P < 0.05$) were observed among samples. The values obtained were lower than the values observed in a breakfast cereal samples made from AYB, Maize and defatted coconut flour at 9.81 – 14.10ppm [36] and also lower than the value of 13.46ppm for a breakfast cereal made from maize, sorghum, soybean and AYB composite flour [34].Inadequate iron intake causes iron deficiency anaemia (IDA) and IDA is a global concern, particularly affecting women and children in developing nations[35].The formulated breakfast cereals contribute to daily iron intake, supporting overall health.

The phosphorus content of the formulated breakfast cereal samples ranged from 62.63 to 71.51ppm with significant ($P < 0.05$) differences among the sample with regards to phosphorus contents. The results obtained were higher than the values (18-28mg/100g) recorded for a breakfast cereal made from blends of Acha and fermented Soybean paste (okara) [1].The results revealed Increased phosphorus content with sesame seed flour addition, but Lower than RDA for adults (350-450mg/100g per day). Phosphorus is an essential mineral primarily used for growth and repair of body cells and tissue. Phosphorus together with calcium provides structure and strength. Phosphorus is also required for a variety of biochemical processes including energy production and regulation. The formulated breakfast cereals contribute to daily phosphorus intake, supporting overall health.

“Consumers’ evaluation of the samples showed that, there were significant ($p<0.05$) differences in the attributes measured between all the samples. In terms of appearance,aroma, flavour, taste and colour, sample D was most preferred when compared to the other samples respectively. The

results have shown that, at the introduction of soybean and sesame seed in the blends, there was a gradual change in the taste, aroma and taste of the samples" [24]. Finally, the mean score for the overall acceptability showed that sample D had the highest mean score of while sample A had the lowest mean values of indicating that the samples with moderate inclusion of the soybean and sesame seed were acceptable and almost like the other samples.

Conclusion

The formulated breakfast cereals had an appreciable amount of nutrients. Sample A revealed a nutritional superiority over the other samples in terms of the mineral constituent of the product, while sample D had the highest content of protein compared with other sample. Supplementation of cereal-based foods with soybean and sesame seed for breakfast meal improved the nutritional composition of the meal. Hence their use should be encouraged as a means of promoting dietary diversity, improving the protein and minerals that can provide a better alternative to the use carbohydrate rich breakfast cereals sold in Nigeria.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Ethical Approval

Ethical approval reference number RUGIPO/NUD/2020/107 was obtained for the study from the Ethic committee of the department of Nutrition and Dietetics Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria

Competing Interests

Author has declared that no competing interests exist.

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