Proximate Analysis, 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 of AOAC 2005 was used to determine the proximate and minerals composition while sensory properties were determined using 9 point hedonic scale. Data gotten were statistically analyzed using ANOVA.

Proximate analysis shows that moisture content ranged from 10.98% in sample D to 12.26% in sample B. Ash content ranged from 3.53% in sample B to 3.82% in sample D. Fat content ranged from 11.81% in sample B to 21.09% in sample D. Protein content ranged from 22.09% in sample A to 26.94% in sample D as well as Carbohydrate content ranged from 35.09% in sample C to 41.91% in sample A. Mineral analysis shows that the sample A had the highest value for sodium (114.55ppm), calcium (161.40ppm), potassium (711.25ppm), magnesium (17.55ppm), iron (3.19ppm) and phosphorus (71.51ppm) with significant difference ($P<0.05$). 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).Acha enriched with soybeans and sesame seeds prevent malnutrition in infants and children.

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

INTRODUCTION

Breakfast in simple term means “breaking the fast” of the night. It is the most important meal of the day because it is the meal which is used to break the fast of the long night usually 10–12 hours [1]. Breakfast is regarded by many nutritionists as the most important meal of the day because food consumed at breakfast seem to be more utilized than the food eaten at night. Most researchers who have studied the effect of eating breakfast have suggested that the benefits are due mainly to the protein that is eaten from the meal because high protein breakfast were found to be better than low protein breakfast

.It helps to maintain a normal blood sugar level between mid-morning and lunch [2]. Breakfast is basically produced from cereals which are the dry seeds of those members of the grass family grown for their grains and are by far the most important plants eaten by man. Cereal is typically a low-fat, nutrient-dense food with many essential vitamins and minerals such as zinc, phosphorus, calcium among others. In addition to delivering important nutrients and essential vitamins such as iron, B-vitamins and zinc, cereals also provide the important benefits of grains[1].

Breakfast cereal was defined to include ready-to-eat breakfast cereal (RTEC), oats/porridge, and muesli [3]. Cereals have been endorsed as the principal source of breakfast's carbohydrates (Marangoni et al. 2009) and allow the consumers to vary their breakfast meal with several different cereal-based products. Breakfast cereals are nowadays available in numerous formulations and have been associated with the reduction of the risk of several chronic diseases in both adults and adolescents (Williams, 2014). For development of breakfast cereals it is important to combine different raw materials to obtain products with the target composition [4].

Other than a good source of available carbohydrates, breakfast cereals can be an important source of micronutrients (e.g., vitamins and minerals) and fibre, such as β-glucans, which play a key role in the prevention of cardiovascular risk, but also in the improvement in appetite control and increase of satiety[5].

Acha (Digitaria exilis and Digitaria iburua) is an annual cereal crop indigenous to West Africa where it is cultivated for its straw and edible grains. It is probably the oldest African cereal. The grains are widely grown in the cool region of plateau state, parts of Bauchi, kebbi, Taraba, Kaduna and Niger states. It is also known with other names as hungry rice, fonio, fundi. Pom and Kunbug in different west Africa has been reported as the oldest Africa cereal [6]. Of the different varieties of Acha grown, the white Acha (Digitaria exilis) is more popular in Nigeria and is more widely grown while the black Acha (Digitaria iburua) is rarely cultivated. The crop has been so neglected that it is called the lost crop of Africa, having received but a fraction of the attention accorded to sorghum, pearl millet, and maize. It has received a mere trifle consideration of its importance in the rural economy and its potential for increasing the food supply.

Comment [D1]: Italics?

Comment [D2]: African cereal

Comment [D3]: Italics species name.

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].

Sesame varieties have adapted to many soil types. The high-yielding crops thrive best on well-drained, fertile soils of medium texture and neutral pH. However, these have low tolerance for soils with high salt and waterlogged conditions. Commercial sesame crops require 90 to 120 frost free days. Warm conditions above 23 °C (73 °F) favor growth and

yields. While sesame crops can grow in poor soils, the best yields come from properly fertilized farms [10].

[11] 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].

The fat in sesame seeds comprises of 38% monounsaturated and 44% polyunsaturated fatty acids [12]. The oil is of high quality, odourless and not likely to become rancid due to the presence of the antioxidants sesame and sesamol, and lignans which are also anticarcinogenic phytosterols which block cholesterol production and prevent high blood pressure as well as increase vitamin E supplies in animals [13].. It also protects the liver from oxidative damage. The main unsaturated fatty acids in sesame oil have been identified to be oleic acid, 40%, and linoleic acid, 40%; and the content of the saturated acids in the oil is about 14% [13].

This study aimed to formulate 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 to be used for this study were obtained from Oja Koko in Owo Local Government Ondo State.

Source of Equipment

All equipment was obtained from the departmental store, these equipment includes Pots, Stoves, Knives, Blender, Spoons, Grater.

Sample Preparation

Preparation of Acha flour

This was produced according to the methods of [1]. Acha grains was manually cleaned and sorted by hand picking of the chaff. Dust and sands was removed by washing severally in tap water using plastic bowls. The washed grains was oven dried at 500C for 6 h, after which the dried grains was finely milled into flour with an attrition mill and sieved to remove coarse and fibrous materials. The resulting flour was stored in air tight polythene bags at room temperature 25oC until needed,

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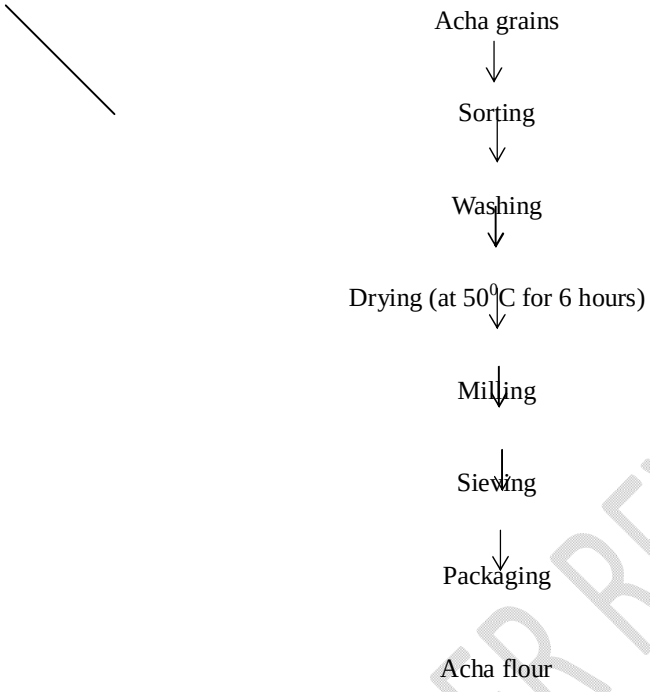

Source: [1].

Figure 1. Modified flow diagram for the processing of Acha into Flour.

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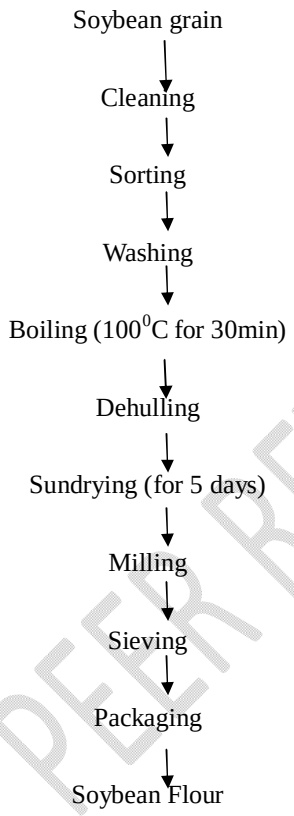
Preparation of Soybean flour

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.

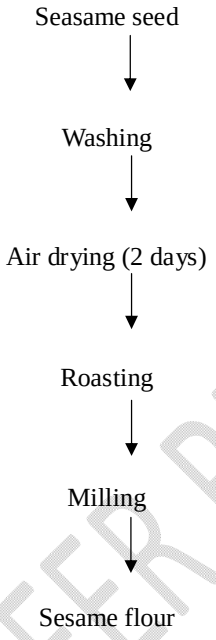


Source; [14].

Figure 2. Flow chart for the processing of Soybean into Flour.

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



- **Sources ; [15].**

Fig 3: Flow chart for the production of sesame flour

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.

Table 1: Formulation of breakfast meal

Comment [D6]: This is repeated many times in text and this table may not be required.

Samples	Acha	Soybean	Sesame seed
A	70	20	10
B	60	25	15
C	50	25	25

D	40	40	20

Determination of Proximate Analysis

Standard laboratory procedures of Association of Analytical Chemist (AOAC, 2012) was used to analyze the samples:

Moisture Content Determination

The standard method of AOAC(2012) was used to determine the content of the samples. Clean petri dish with lid was labelled and dried in an oven at 1000C for 30minutes, then cooled in a desiccators containing reignited CaO as desiccant and weighed to a constant weight (W1) using mettle balance scale. the sample (5.0g) was weighed into petri dish. The dished and sample was weighed again before drying (W2). The petri dish and sample was transferred into the oven (Galeonkamp size 3, hot box, London, UK) maintained at 1050C for 3hours. The dish and the content was removed and quickly transferred into a desiccator containing CaO as desiccant to cool and re-weighed. The sample was returned into the oven and re-dried for further one hour, cooled and weighed. The procedure was repeated until a constant weight was attained (W3). Triplicate analysis was determined on the sample.

Comment [D7]: Is it 1050? Or 105DegC?

Calculation

The moisture content of each samples was calculated as the difference in weights before and after drying to constant weights. Values was expressed as percentage moisture.

Percentage moisture content=

W1= weight of sample

W2= weight of sample + petri dish

W3= weight of sample + petri dish (constant weight after drying)

Crude Fat Content Determination

The crude fat content was determined by using soxhlet apparatus as described by AOAC (2012). Sample (0.5g) was weighed into thimble and fixed into the soxhlet extractor, n-hexane was used as the solvent. The hexane was poured into a round bottom flask and placed on the heating mantle. The extraction was done continuously for about 31/2hours after which the flask was cooled and disconnected. The thimble with sample was removed and dried to a constant weight in hot air oven at 500C. The difference between the weight of thimble before and after extraction was recorded in order to obtain the crude fat extracted. The percentage crude fat content will then be calculated and expressed on dry basis.

Percentage of crude fat=

W1= weight of sample

W2= weight of sample + filter

W3= weight of sample + filter (constant weight after drying).

Crude Protein Content Determination

Digestion Stage: This was determined by kjeldahl method as described by AOAC (2012). The sample (1.0g) was weighed into a kjeldahl flask and (3.0g) of hydrated cupric sulphate (catalyst), twenty (20ml) of sodium sulphate solution (Na_2SO_4) and (0.1ml) of concentrated sulphuric acid (H_2SO_4) was added to sample in the flask. The flask was clamped and heated inside a fume cupboard until the solution become colourless.

Distillation Stage: The clear solution was cooled, diluted with distilled water made up to 100ml. 10ml of the resulting was mixed with 5ml of 40% sodium hydroxide solution in a distillation flask and distilled to release ammonia.

Titration Stage: The resulting solution above was titrated with 0.1ml hydrochloric acid (HCL). The titre value or end point at which the colour from green to pink was noted and the end protein was calculated using the expression.

Crude protein (%)=

Where:

VF= Total volume of the digest=100ml

W= Weight of the sample digested

T= Titre value

6.25= Conversion factor

N= Normality of HCL in moles per 100ml (0.1N)

Total Ash Content Determination

The total ash content of the sample was determined as described by AOAC (2012). The crucibles used was washed, dried in the air oven and allowed to cool in a dessicator. The crucible was weighed and 1g of the sample was weighed into the crucible. The crucible and its contents was transferred into a muffle furnace set at 5500C. the ashing was continued until no black speck or white grey ash was obtained, the crucibles was taken out and immediately covered and was placed in a dessicator to cool..

Percentage of Total Ash=

W1= weight of sample

W2= weight of sample + crucible

W3= weight of sample + crucible (constant weight after drying).

Crude Fibre Content Determination

The crude fibre content was determined as described by AOAC (2012). Sample (5g) was weighed (W1), and transferred to a fat extraction apparatus, it was extracted with light petroleum. The sample was transferred to a dry 500ml conical flask and about 200ml of boiling 1.25% sulphuric acid was added and brought to boiling within 1minutes. The content was allowed to boil gently for 30mins, it was filtered through a muslin cloth, it was rinse well with distilled water and scraped back into flask using spatula.

Simple procedure was followed using 1.25% sodium hydride after which it was rinsed once with 10% HCL, four times with distil water and finally with ethanol. The treated sample was sewage into pre-weighed and drained silica dish, oven dried for 12hours at 1050C, cooled and weighed (W2). The samples was finally ashed at about 5500C for 2hours, then cooled in a desiccators and re-weighed (W3).

Percentage of Crude Fibre=$\frac{\text{weight loss(W2-W3)}}{}$

W1= Initial weight of sample

W2= Weight of sample + crucible before ashing

W3= Weight of sample + crucible after ashing (constant weight after drying

Comment [D8]: These are standard protocols and can be written in one or few lines.

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 hollow cathode individual metals 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 was 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.

Comment [D9]: Provide reference.

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 was 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

Table 2 shows the proximate composition of formulated breakfast cereal from acha enriched with soybean and sesame seed flour. Moisture content shows that Sample A (70% Acha; 20% soybean; 10% sesame seed) and B (60% Acha; 25% soybean; 15% sesame seed) had the highest value 11.50% and 12.26% respectively while sample D (40% Acha; 40% soybean; 20% sesame seed) had the least value of 10.98%. Sample A (3.81%) and D (3.82%) had the highest ash content while sample B (3.53%) had the lowest value. 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 had the highest value of 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 2 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 ($P<0.05$).

Key; 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**,** Sample D = 40% Acha; 40% soybean; 20% sesame seed

Comment [D10]: Can be omitted.

Mineral composition of the formulated breakfast cereal

Table 3 shows the mineral composition of formulated breakfast cereal from acha enriched with soybean and sesame seed flour. Sample A (70% Acha; 20% soybean; 10% sesame seed) had the highest value of sodium (114.55ppm) while sample C (50% Acha; 25% soybean; 25% sesame seed) had the lowest value of 101.55ppm. sample B and D contained 105.85ppm and 102.75ppm respectively with significance difference ($p<0.05$). Sample A (161.40) had the highest calcium content while sample D has the lowest value (135.50ppm). The potassium content of sample A (711.25ppm), B (645.75ppm), C (638.35ppm) and D (695.75ppm) were significantly different $p<0.05$. Sample A had the highest potassium content while sample C had the lowest potassium content. In terms of potassium content, Sample D (319.92ppm) had the highest value while sample A (156.40ppm) had the least content with significant difference. Sample A had the highest value of zinc (1.95ppm) while sample B had the lowest value of 1.51ppm with significant difference ($p<0.05$). The table also showed the magnesium and iron contents of the samples; Sample A contains the highest value of 17.55ppm and 3.19ppm for magnesium and iron content respectively while sample D (10.92ppm) and sample C (2.38ppm) had the least value for magnesium and iron contents. Result also shows that sample A (71.51ppm) had the highest value of phosphorus while sample D (62.63ppm) had the highest value of phosphorus.

Comment [D11]: Poor writing. Rewrite in terms of each mineral or breakfast composition.
Ex: A is having highest values of all the seven minerals analysed.

Comment [D12]: Reckless writing. Sample D has the least value of P.

Samples (ppm)	Na	Ca	K	Zn	Mg	Fe	P
A	114.55±0.21[a]	161.40±0.14[a]	711.25±0.07[a]	1.95±0.04[a]	17.55±0.02[a]	3.19±0.01[a]	71.51±0.02[a]
B	105.85±0.07[b]	147.30±0.14[c]	645.75±0.21[c]	1.51±0.04[d]	13.74±0.01[c]	2.78±0.01[c]	65.26±0.04[c]
C	101.55±0.35[d]	155.75±0.21[b]	638.35±0.21[d]	1.66±0.01[c]	16.52±0.04[b]	2.38±0.03[d]	66.96±0.04[b]
D	102.75±0.45[c]	135.50±0.00[d]	695.75±0.07[b]	1.73±0.02[b]	10.92±0.01[d]	2.81±0.04[b]	62.63±0.03[d]

Table 3: Mineral composition of the formulated breakfast cereal

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).

Key; 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**,** Sample D = 40% Acha; 40% soybean; 20% sesame seed

Comment [D13]: Omit this

Sensory Evaluation of the formulated breakfast cereal

Table 4 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 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 4 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 ($P<0.05$).

Key; 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, Sample D = 40% Acha; 40% soybean; 20% sesame seed

Comment [D14]: Wasted lot of time. Couldnot enjoy reviewing this manuscript. My day is wasted.

DISCUSSION

Moisture content ranged from 10.98% to 12.26%. These values are higher than 5.05% to 9.35% reported for Acha-soy breakfast gruel [16]. Sample B formulated from 60% Acha, 25% soybean and 15% sesame seed contained the highest value while sample D had the least value of 10.98%. The decrease in moisture content in sample D could be due to increase in protein content as a result of soybean, and protein has more affinity to moisture than carbohydrate [17]. This could be an advantage to the keeping quality and shelf-life of the flours. There is less microbial growth when moisture is less available.

The result for ash content ranged from 3.53% in sample B to 3.82% in sample D. These values are higher than to 1.41% to 2.06% reported by [1] for breakfast cereals from blends of acha and fermented soybean paste. The ash content of the samples products increased with increase in Acha and soybean. This increase could be due to more mineral content of Acha grain and soy [18]. Ash content indicates the presence of mineral matter in food. 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 [19].

Fat content of the formulated breakfast cereal ranged from 11.81% to 21.09%. These values are higher than 1.89% to 10.23% reported for breakfast cereal from fermented Acha, roasted Soybean and carrot [20]. Sample D had the highest value while sample B had the least value (11.81%). The fat content in the breakfast meals showed a significant level of increase with increase in soybean in the formulations. This showed that the breakfast flours were high energy products because of the fat content. This increase was due to the addition of soybean being a good source of oil [14].The flours being rich in fat provided the energy requirements for bodily activities as computed in the data by [21] and [22].

Crude fiber of the samples ranged from 5.74% to 6.25%. These values are higher than 1.87% to 2.72% for breakfast cereals produced from germinated spring grain flakes [4]. Sample C had the highest value while sample A contained the least value (5.74%). The crude

fibre contents were high in formulated samples of higher sesame seed.. It is known that whole grains of sesame seed are good source of dietary fibre and are used in the prevention and treatment of constipation, cardiovascular diseases and hypertension [23].The health benefits of sesame seed products are now widely recognized and considered to result from the presence of bioactive components, including dietary fibre and phytochemicals [24].

Protein content of the formulated samples ranged from 22.09% to 26.94% with sample D having the highest value and sample A having the least content. These values are lower than 6.92% to 19.60 reported by[16]. This showed that as soybean increased, the protein content also increased. There was a significant ($p<0.05$) difference between the samples. This could be due to the high percentage of fat in soybean which agreed with the result of [25]. The protein content of sample D formulated with 40% acha, 40% soybean and 20% sesame seed was 26.94% which agreed to the result given by FAO [22].

Carbohydrate content of the samples ranged from 35.09% to 41.91%. These samples are higher than 59.48% to 77.28% reported by [16]. The 70% whole meal Acha flour had the highest percentage carbohydrate content of 41.91%. The substantial carbohydrate content of whole meal Acha has made it a complement to the diet for diabetic individuals. It has been found that consumption of whole Acha grains by diabetic patients helps them recover due to its low glycemic index [26]. The whole grain Acha is rich in fermentable carbohydrate that reaches the gut. Whole grain breakfast cereal has been shown to be more effective than wheat bran breakfast cereal as a prebiotic, increasing faecal bifido bacteria and lactobacilli in human subjects [27].

The result of the sodium content ranged from 101.55ppm to 114.55ppm/. These values are lower than 600.86 to 701.35ppm reported for breakfast cereal from Pearl Millet, Irish Potato and Sesame Seed Blend [28]. Sample A had the highest value while sample C had the least value. The generallow amount of sodium in the product could be attributed to the low amount of salt added during the preparation of the breakfast cereal. The formulated breakfast cereal products recorded low sodium content, it implies that the product may be ideal for adults. Diets containing foods that are good source of low in sodium may reduce the risk of high blood pressure and stroke[29].

Calcium content ranged from 135.50ppm to 161.40ppm with the highest observed in sample A while the least value occurred in sample D.. These values are lower than 1.97 to 3.23ppm obtained for breakfast cereals from blends of acha and fermented soybean paste [1]. The calcium content values obtained in this study met with the RDA for calcium (100ppm). Thus, the formulated samples could provide about 15.6-18.4% of the RDA. Calcium is one of the most important minerals that the body requires and its deficiency is more prevalent than any other mineral [30]. Since the formulated breakfast cereal samples contained a significant amount of the element, they could make an ideal meal for children and adult alike.

Potassium content ranged from 638.75 to 711.25ppm. These values are higher than 70.62 to 78.53ppm reported for breakfast cereals from flour blends of maize (zea mays) and jackfruit (Artocarpus heterophyllus Lam.) Seeds [31].There were significant differences ($P < 0.05$) among the samples with the highest value observed in the sample A and the least observed in sample C. It was also observed that there was consequent decrease in the potassium content with an increase in the amount of acha flour in the formulation. The range of potassium content were also lower than the values of 88.00 to 191.00ppm recorded for a breakfast cereal made from AYB, Maize and defatted coconut flour [32]but higher than the US RDA for both men and women (3.5mg/100g). Potassium is primarily an intercellular cation, mostly this cation is bound to protein and with sodium influences osmotic pressure and contribute to normal pH equilibrium [33].

The zinc content of the formulated breakfast cereal samples ranged from 1.51 to 1.95ppm with the highest value recorded in sample A and the least value recorded in sample B. The result also showed a reduction in the zinc content with subsequent increase in the amount of soybean flour added to the formulation. Higher values were observed for a breakfast cereal sample made from soybean and sesame seed (1.73ppm). Lower values of 1.54 to1.64pp, were also recorded for fortified breakfast cereal reported [34]. Zinc is a component of every living cell and plays a role in hundreds of bodily functions, from assisting in enzyme reaction to blood clotting and its essential for taste, vision and wound healing [35].

Themagnesium contents of the cereal ranged from 10.92ppm to 17.55ppmwith significant differences ($P < 0.05$) in the magnesium content among the formulated breakfast cereal samples. The highest value was recorded for sample A and the least was recorded for sample D. These magnesium values were lower than those recorded by[36] for a breakfast cereal made from AYB, Maize and defatted coconut flour with values ranging from 290.02mg/100g to 430.01mg/100g. Magnesium is an activator 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 cereal could make an ideal meal for both men and women since it contained a significant amount of the element.

The iron content of the formulated breakfast cereal ranged from 2.38 to 3.19ppm with the highest value recorded for the sample A and the least for sample D. Significant ($P < 0.05$) differences were observed in all the samples with regards to iron content. 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 it is very common around the world especially for women and children in developing nations. Symptom of iron deficiency include; fatigue, weakness and shortness of breath [35].

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 highest value was observed in sample A (71.51ppm) while the least value was observed in sample D (62.63). 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 that the phosphorus content of the formulated samples increased with increasing addition of the sesame seed flour in the formulation, although the values obtained were less than the US RDA (350-450mg/100g for adults) per day. Phosphorus is an essential mineral primarily used for growth and repair of body cells and tissue. Phosphorus together with calcium provide structure and strength. Phosphorus is also required for a variety of biochemical processes including energy production and regulation.

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 (5.10), aroma (5.25), flavour (5.70), taste (4.60) and colour (5.60), sample D (40% Acha; 40% soybean; 20% sesame seed) was most preferred when compared to the extend samples whose ranges for these attributes were 3.65 to 5.10; 3.60 to 5.25; 3.60 to 5.70; 3.85 to 4.60 and 4.35 to 5.60 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.

Finally, the mean score for the overall acceptability showed that sample D had the highest mean score of (6.50) while sample A had the lowest mean values of 4.80 indicating that the samples with moderate inclusion of the soybean and sesame seed were acceptable and almost like the other samples.

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