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MINERAL AND AMINO ACID COMPOSITION AND STORAGE CONDITION OF BREAK FAST CEREAL MADE FROM SORGHUM (*Sorghum bicolor L*) SOYBEAN (*Glcyine max*), BAMBARA GROUNDNUT (*Vigna subterranean*) AND GROUND NUT (*Arachis hypogaea*)

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ABSTRACT: In tropical developing countries where the supply of minerals and protein from animal source is inadequate to meet the rapid population growth, intense research efforts are currently directed towards identification and evaluation of food grains which normally have considerable high protein and mineral content. The major objective of this research study is to investigate the mineral and amino acid composition and storage condition of breakfast cereal made from sorghum, soybean, Bambara nut and groundnut with a view to increase the nutrients content. Using standardized method, ten samples were formulated by mixing the flours in ratio of (Sorghum flour and 5% of malted sorghum flour) with graded levels of bambara nut flour (80:20, 70:30, 60:40); soybean flour (80:20, 70:30, 60:40) and defatted groundnut flour (80:20, 70:30, 60:40). The formulated flours were subjected to mineral and amino acid determination, microbial analyses, rancidity test and consumer acceptability. The results revealed that mineral composition of the formulated breakfast cereals showed that significant differences ($p<0.05$) exist between the samples in almost all the parameters studied. The calcium content of the products ranged from 124.54 to 411.36 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. The iron content of the products ranged from 1.23 to 12.46 mg/100g. The magnesium content of the products ranged from 62.35 to 124.54 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. The magnesium content of the products ranged from 62.35 to 124.54 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. The phosphorus content of the products ranged from 84.54 to 365.65 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. There were significant differences ($p<0.05$) in the amino acid profiles of the developed breakfast cereals. The values increased with the increase in the level of the Bambara nut, soybean and defatted groundnut substitutions. The results reveal that the samples contained varying amounts of both essential and non-essential amino acids. The microbial examination of the products revealed different values for total bacteria count (TBC), total coliform count (TCC), and total fungi count (TFC). The TBC ranged from 3.85×10^5 to 6.06×10^5 cfu/ml, while the TCC ranged between 1.50×10^5 to 3.36×10^5 cfu/ml and the TFC ranged from 4.98×10^5 to 9.77×10^5. The peroxide value (PV) of freshly made samples had a mean value of 5.51 meq/kg, and the maximum PV that most of the samples attained during their course of storage was 6.90 meq/kg. The time when the samples exhibited the maximum PV. varied for each sample depending on the temperature as well as the storage condition. The data obtained from the study were analyzed using ANOVA while the means were separated by Duncan multiple range test. Sample F recorded superior score for appearance and aroma but textural characteristic comparable to sample D

INTRODUCTION

The changes in lifestyle and rapid urbanization in recent years have resulted in an increase in the consumption of cereal-based products in most developing countries. Also, with the increased interest in the exploitation of less-common oilseeds and sorghum having limitations of some essential amino acids particularly lysine, while legumes and oilseeds are rich in both protein and lysine, but usually deficient in sulphur containing amino acids (methionine and cystine) can form good complements for each other.(Ijarotimi and Keshinro, 2012). Therefore, it is often emphasized that legume protein and oil seeds are the natural supplement to cereal grain to improve the level of essential amino acid.

In tropical developing countries where the supply of animal protein is inadequate to meet the rapid population growth, intense research efforts are currently directed toward identification and evaluation of food grains which normally have considerable high protein content. Such studies are of great importance to reduce hunger and malnutrition among the vulnerable group which basically consist of children and pregnant women. Sorghum after maize is the second most important cereal food in Africa (Mokrane *et al.*2010). It is of great nutritional importance in the diets of millions of rural dwellers in the semi-arid and arid tropics, and utilized in the production of many traditional foods and in bakery productions like bread, cakes and biscuit Hafiz Abubakar 2010). However, products made from sorghum grains are deficient in essential amino acids such as lysine, methionine, and tryptophan. Also the presence of anti-nutritional factors such as tannins and phytates limit their nutritional value (Award *et al.*2012).Soybean (*Glycine max*) is a good source of protein that is superior to all other plant foods because it has good balance of the essential amino acids lacking in sorghum, making it a good supplement for cereals(Mokrane *et al.*2010). Nutritionally, soybeans are rich in lysine but deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids. Thus, addition of soybean flour to cereal based products could be a good option to provide better overall essential amino acid balance, thereby helping to overcome the world protein calorie malnutrition problem (Correia *et al.*2010). Bambara groundnut as a legume is high in protein that play important role in human nutrition. A detailed study shows that it contains 20-26% crude protein (high in lysine; 6.6%); and makes an excellent source of supplementing proteins in the diet. Also, ground nut (*Arachis hypogea*) is very high in calories due to its high fat and protein contents. Ground nuts are reasonable sources of dietary minerals especially potassium, phosphorous and magnesium, however they are poor source of vitamins such as vitamin A, D and K. Ground nut oil is an excellent source of mono and polyunsaturated fatty acids exceeding the levels of these fatty acids in soybean and corn oil but significantly lower than that of sunflower and safflower oil. Therefore based on these effort mention nutrients, any effort made to blends them will increase the nutrients content of the end product like breakfast cereal product. Therefore this study is an attempt to investigate the mineral and amino acid composition and storage condition of breakfast cereal made from sorghum, soybean, bambara nut and groundnut with a view to increase the nutrients content.

MATERIALS AND METHODS

Experimental Location

The experiments were carried out in the laboratory of Food Science and Technology, Modibbo Adama University of Technology, Yola Adamawa State.

Research Materials

Grain samples

Sorghum, soybean, bambara nut and ground nut grains were purchased from Jimeta modern market. All samples were kept in a moisture free environment until when needed.

Chemicals and Reagents

The chemicals and reagents used were of analytical grade and were obtained from the laboratory of Food Science and Technology, Modibbo Adama University of Technology, Yola Adamawa State.

Methods

Preparation of sorghum flour and malted sorghum flour

The sorghum flour sample was prepared as described by Anglani (1998) with little modifications. The sorghum was sorted to remove extraneous materials and damaged seeds. Thereafter, one kilogram (1kg) of the grains was steeped, dehulled, dried and milled to fine powder. A local sieve of about 250 μm was used to sieve the flour in order to obtain a fine particle size. The flour was packaged in a plastic container and sealed until when needed.

Preparation of malted and unmalted samples

The sorghum cultivar was malted as described by Badau *et al.* (2006). The bambara nut flour samples was prepared as described by Nwosu (2013) with little modifications. The defatted groundnut flour sample was prepared as described by Juliana and Zhengxing (2008) also with little modifications while Soy flour was prepared according to the method described by Bolarinwa *et al.*(2015)

Formulation of Breakfast Meal

The Breakfast meal was formulated using sorghum, soybean, bambara nut and defatted ground nut flours in the following ratios (Table 1). The flours were blended into fine powder using a Kenwood blender by the method described by Badau(200).

Table 1: The Percentage Ratio of the Breakfast Meal Formulation (%)

Sample Code	MSF+SF	BNF	SBF	GNF
A	100	-	-	-
B	80	20	-	-
C	80	-	20	-
D	80	-	-	20
E	70	30	-	-
F	70	-	30	-
G	70	-	-	30
H	60	40	-	-
I	60	-	40	-
J	60	-	-	40

KEY:

MSF = 5% of malted sorghum flour, SF = Sorghum flour, BNF = Bambara nut flour,

F = Soybean flour, GNF = Defatted groundnut flour, A= MSF & SF 100%, B= MSF & SF 80% + BNF 20%, C= MSF & SF 80% + SBF 20%, D= MSF & SF 80% + GNF 20%, E= MSF & SF 70% + BNF 30%, F= MSF & SF 70% + SBF 30% ,
G= MSF & SF 70% + GNF 30% , H= MSF & SF 60% + BNF 40% , I= MSF & SF 60% + SBF 40%, J= MSF & SF 60% + GNF 40%

Determination of Mineral Content

The mineral content of the formulated samples were evaluated using the method described by Anigo *et al.*(2010). One gram of dried sample was digested with 2.5ml of 0.03N hydrochloric acid (HCl). The digest was boiled for 5 minutes, allowed to cool to room temperature and transferred to 50ml volumetric flask and made up to the mark with diluted water. The resulting digest was filtered with ash-less Whatman No. 1 filter paper. Filtrate from each sample was analyzed for mineral (calcium, Iron, magnesium, manganese, phosphorus, potassium and zinc) 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.

Determination of Amino Acids Profile

The method of Sotelo *et al.,* (1994) was used in determining the amino acid content of the samples. One gram of sample was dissolved in 20ml of 6N HCl. This was then poured into a hydrolysis tube with a screw cap and hydrolyzed for 22hr under a nitrogen atmosphere. The acid was evaporated using a rotary evaporator and residue washed three times with distilled water. The extracted sample was dissolved in 1ml acetate buffer (pH 3.1), then filtered through membrane filters. The hydrolyzate was transferred into a Beckman system (model 6300) high performance amino acid analyzer. Amino acid scores were calculated as gram per 100 gram protein (g/100g protein).

Rancidity Test of Breakfast Cereals Flour

The samples were packed in transparent polythene nylon bag. The shelf-life of the sample A to J were studied for a period of 24 weeks at ambient conditions (27 to 35°C).

Microbial Analysis

The microbial analysis was carried out according to method described by Jideani and Jideani (2006)

Sensory Evaluation of Breakfast Cereal Flour

The developed breakfast flour bends was served to 10 untrained panel members who were asked to ranked the products on the basis of their quality attributes (appearance, taste, aroma and texture) using 9 points hedonic scale, where 1 = 'dislike extremely' and 9 = 'like extremely as described by (Ihekoronye and Ngoddy(1985) for consumer acceptability. Results were obtained from the sensory evaluation were tested at 5% level of significance.

Statistical Analysis

All the data reported in this study were carried out in triplicate. In each case, a mean value and standard error were calculated. The data were analyzed using SPSS version 20 statistical software. Statistical parameters were estimated with analysis of means (ANOVA). Differences between means were evaluated by the Duncan multiple range test and significance was accepted at 0.05 ($p < 0.05$)

RESULTS AND DISCUSSION

Mineral Composition of Breakfast Cereals

The mineral composition of the formulated breakfast cereals is shown in Table 2. Generally, significant differences ($p<0.05$) existed between the samples in almost all the parameters. The calcium content of the products ranged from 124.54 to 411.36 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value.

These values were higher than the values obtained from the work of Anigo *et al.* (2010) for breakfast cereals made from malted cereals maize, soybeans and groundnut. Calcium is by far the most important mineral that the body requires and its deficiency is more prevalent than any other mineral (Davis *et al.*,2016) Calcium, Phosphorus and vitamin D combine together to eliminate rickets in children and osteomalacia (the adult rickets) as well as osteoporosis (bone thinning) among older people(Bao *et al.*,2013). Since this products produced contain significant amounts of the element they can make an ideal meal for children and adults alike.

The iron content of the products ranged from 1.23 to 12.46 mg/100g. The values obtained in this study lies within the range of the US RDA (10-15mg/100g). Similar result was reported by Agunbiade and Ojezele (2010)for breakfast cereals made from maize, sorghum, soybeans and AYB composite. When foods with iron are eaten, it is absorbed into proteins and helps these proteins take in, carry, and release oxygen throughout the body. An iron deficiency called iron-deficiency anemia is very common around the world, especially for women and children in developing nations. Symptoms of iron deficiency take years to develop and include fatigue, weakness, and shortness of breath (Bao *et al.*,2013)

The magnesium content of the products ranged from 62.35 to 124.54 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerve. It works with calcium to assist in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions (Bao *et a l.*, 2013) The manganese content of the products ranged from 6.35 to 32.54 mg/100g. This value falls within the higher tolerable upper intake value of 11mg/100g. Manganese functions as an essential constituent for bone structure, for reproduction and for normal functioning of the nervous system; it is also a part of the enzyme system. Manganese is readily found in nuts, whole grains, leafy vegetables, and tea.

The phosphorus content of the products ranged from 84.54 to 365.65 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60%

MSF+SF and 40% SBF) had the highest value. The observed increase in the phosphorus level of the products could be as a result of nutrients resident in sorghum, soybean, bambara nut and deffated-groundnut before metabolism. Thus, supplementation of the sorghum flour with soybean, bambara nut and deffated-groundnut flour increased the phosphorus. Highest values of phosphorus minerals were observed in blends containing malted sorghum and soybean flour (Sample I) than in other products. Therefore, germination increased the levels of the minerals in the breakfast cereal products.

The potassium content of the products ranged from 365.54 to 1243.27 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. Potassium is primarily an intercellular cation, in large part this cation is bound to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrium Okafor and Usman (2015). The zinc content of the products ranged from 0.36 to 6.35 mg/100g, with sample A (100% MSF+SF) having the lowest value and sample I (60% MSF+SF and 40% SBF) had the highest value. Okafor and Usman (2015) recorded similar values for fortified breakfast cereals as 1.54±0.30mg/kg and 1.64±0.4mg/kg. Zinc is a component of every living cell and plays a role in hundreds of bodily functions, from assisting in enzyme reactions to blood clotting, and is essential to taste, vision, and wound healing (Okafor and Usman (2015). The decreased level observed in some of the minerals may be associated with the processing techniques. Vegetable protein-containing raw materials were lost during soaking, boiling and frying. In any situation body mineral is threatened, supplementation may be contemplated..

Amino Acid Profile of Breakfast Cereals

The results obtained for amino acid profile of the developed breakfast cereals are shown in Tables 3a and 3b.There were significant differences ($p<0.05$) in the amino acid profiles of the developed breakfast cereals. The values increased with the increased in the level of the bambara nut, soybean and defatted groundnut substitutions. The results reveal that the samples contained varying amounts of both essential and non-essential amino acids. Proline, histidine, isoleucine, methionine, phenylalanine, threonine, tryptophan, valine, arginine, alanine, cysteine, glycine, and serine recorded the least values, while higher values were recorded for leucine, lysine, aspartate, tyrosine, and glutamate. It is important to note that the consumption of these products will make up for all the required amino acids required. Although proteins from plant sources tend to have a relatively low biological value, in comparison to protein from eggs or milk, they are nevertheless complete in that they contain at least trace amounts of all of the amino acids that are essential in human nutrition. Eating various plant foods in combination can provide a protein of higher biological value (Okafor and Usman, 2015). Asma *et al.* (2006) reported that the blending of lysine-deficient sorghum with high-lysine legume improved the acid profile of amino acids, in particular lysine but the improvement was at the expense of sulfur-containing amino acids. When compared with recommended values of FAO/WHO/UNU for complementary foods, it was observed that all products fell below recommended values of essential amino acids in complementary foods in children between 9-11 months. The reduction in amino acids may be attributed to the denaturation of the protein during the heat treatment. Among the non-essential amino acid alanine, arginine, aspartic acid and glycine are markedly decreased after cooking.

Microbial Examination of Breakfast Cereals

The microbial examination of the products revealed different values for total bacteria count (TBC), total coliform count (TCC), and total fungi count (TFC) as shown in Figure 1 and Table 7. The TBC ranged from 3.85×10^5 to 6.06×10^5 cfu/ml, while the TCC ranged between 1.50×10^5 to 3.36×10^5 cfu/ml and the TFC ranged from 4.98×10^5 to 9.77×10^5. The contamination could have occurred during cooling and before packaging. Yeasts are commonly present as contaminants in cereals and can probably be attributed to the low value of the pH which creates ideal conditions for yeast growth. The presence of microflora may also be due to availability of more nutrients for microbial proliferation and enhanced metabolic activities. These results are much lower than the FAO/WHO limits of 10^4 to 10^6cfu/g for bacteria and 10^2 to 10^4 cfu/g for moulds in weaning foods (Abdulkadir and Danjuma, 2015).Thus ,the microbial analysis of the formulated flour blends reveals that all the formulation indicated a safety of the products for consumption and this could be due to higher standard of personal hygiene and quality maintenance of manufacturing practice observed during the preparation. C highlighted the importance of adequate hygiene during the preparation of food and also link between infection and nutrition. Different proteins are composed of different amino acids. Some of these amino acids can be synthesized by living organisms from other nitrogen materials, the amino acids which are being synthesized vary among different higher animals. Those which cannot be synthesized in vivo are known as the essential or indispensable amino acids and must be provided by the food which is eating. Of the eighteen edible amino acids, eight are now acceptable as essential for adults; Lysine, methionine, phenyl alanine, threonine, tryptophan, valine, leucine and Isoleucine. In addition, infants are believed to require Histidine. Amino acids are the essential buildings materials of which all animal tissues and organs are composed and maintained. The nutritive value of food, especially protein mostly would depend not only on its amino acid profile in general but also on the quantities of the essential amino acids content in particular. The nutritive value of dietary protein is determined by the pattern and quantity of essential amino acids present.

Rancidity Test of Breakfast Cereals Flour

Table 4: shows the results obtained from the rancidity test. There were no noticeable changes observed up to 16 weeks of storage in case of peroxide value. During storage of samples it was noticed that peroxide value increased slowly and steadily. So all the samples w became less crisp and taste changing to rancid. After passing time these defaults become higher. The peroxide value (PV) of freshly made samples was a mean value of 5.51 meq/kg, and the maximum PV that most of the samples attained during their course of storage was 6.90 meq/kg. The time when the samples exhibited the maximum PV.varied for each sample depending on the temperature as well as the storage condition. In general, the peroxide values seemed to increase steadily from the initial value until a maximum was reached and then the value' started decreasing, which is in tune with the normal trend of peroxide formation during oxidation of fatty foods. During this process, peroxides are formed at first by-product of fat oxidation, and then they gradually decompose into secondary by-products. Refrigerated storage conditions were ideal for storage of Sample A to J. No significant change occurs in the samples under refrigeration even after 24 weeks of storage. Under room conditions, Sample G to J performs the best with no significant rancidity development before 14-15 weeks of storage time.

Around that time, the peroxide values start dropping. From the experiments, it was observed that storage temperature had a more pronounced effect on the development of rancidity than the humidity to which the samples were subjected. It can be clearly seen that the samples stored under refrigerated conditions take longer to show signs of rancidity for Peroxide Values.

Sensory Evaluation of Breakfast Cereals Flours

The results of sensory evaluation of the flours formulated for the production of breakfast cereals from 50 semi-trained panelists were graphically presented in Figure 1. The degree of difference among the flour samples was compared by Duncan's Multiple Range Test (DMRT) at 95% probability level. In terms of appearance, the scores ranged from 1.00 to 9.00 with the sample H, 60% MSF+SF and 40% BNF having the lowest score while sample F, 70% MSF+SF and 30% SBF had the highest score thereby the most preferred by the panelists. The appearance of sample F was most preferred due to high addition of 5 % malt sorghum flour samples. This result agrees with Ijarotimi and Keshinro (2012) for formulated weaning food gruel produced from germinated popcorn, bambara Groundnut and African locust bean flour.In term of aroma, the scores ranged from 1.80 to 9.00 with the sample C, 80% MSF+SF and 20% SBF having the lowest score while sample F, 70% MSF+SF and 30% SBF had the highest score thereby the most preferred by the panelists.The textural attributes of dried samples play a significant role in consumer appeal, buying decisions and eventual consumption (Hussein *et al.*, 2018). The scores of the texture ranges from 4.00 to 8.87 with sample I, 60% MSF+SF and 40% SBF having the lowest score while sample B, 80% MSF+SF and 20% BNF had the highest score thereby the most preferred by the panelists.

CONCLUSION

This research study is aimed at determining the mineral, amino acid composition and storage condition of breakfast cereals made from blends of sorghum flour, soybean flour, ground nut flour and Bambara nut flour. The formulated flours were subjected to mineral, amino acid composition and storage condition of breakfast cereal. The sensory evaluation findings show that good and acceptable breakfast cereals with adequate mineral and amino acid profile can be produced using blends of sorghum, soybean, bambara nut and defatted groundnut. This will reduce the pressure in using only wheat for breakfast food and also diversify the uses of sorghum, soybean, bambara nut and defatted groundnut flour.

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Table 2: Mineral Composition of the Breakfast Cereal Produced from Blends of Sorghum, Soybean, Bambara nut and defatted Groundnut (mg/100g)

Sample	Calcium	Iron	Magnesium	Manganese	Phosphorus	Potassium	Zinc
A	124.54 ± 0.47^{j}	1.23 ± 0.18^{j}	62.35 ± 0.28^{j}	6.35 ± 0.17^{j}	84.54 ± 0.47^{i}	365.54 ± 0.47^{j}	0.36 ± 0.29^{j}
B	162.27 ± 0.55^{i}	2.66 ± 0.59^{i}	68.64 ± 0.57^{i}	13.25 ± 0.27^{i}	96.35 ± 0.28^{h}	451.65 ± 0.58^{i}	1.86 ± 0.81^{i}
C	251.35 ± 0.30^{e}	4.57 ± 0.49^{f}	78.65 ± 0.60^{f}	17.67 ± 0.12^{g}	124.64 ± 0.57^{e}	845.65 ± 0.60^{c}	4.54 ± 0.49^{e}
D	215.65 ± 0.60^{f}	3.95 ± 0.30^{h}	76.86 ± 0.79^{g}	16.29 ± 0.12^{h}	117.83 ± 0.78^{f}	714.27 ± 0.22^{f}	3.43 ± 0.36^{f}
E	177.12 ± 0.70^{h}	4.16 ± 0.85^{g}	75.43 ± 0.36^{h}	20.15 ± 0.17^{f}	102.14 ± 0.29^{g}	486.33 ± 0.28^{h}	2.32 ± 0.27^{h}
F	279.26 ± 0.19^{c}	6.26 ± 0.21^{d}	87.97 ± 0.29^{d}	23.46 ± 0.11^{e}	285.65 ± 0.60^{c}	915.26 ± 0.21^{b}	4.76 ± 0.69^{c}
G	251.68 ± 0.63^{d}	7.12 ± 0.70^{c}	79.65 ± 0.58^{e}	24.64 ± 0.32^{d}	254.97 ± 0.92^{d}	762.36 ± 0.31^{e}	4.63 ± 0.58^{d}
H	205.32 ± 0.27^{g}	5.25 ± 0.75^{e}	92.30 ± 0.25^{c}	29.07 ± 0.27^{b}	124.65 ± 0.58^{e}	572.65 ± 0.60^{g}	3.26 ± 0.19^{g}
I	411.36 ± 0.29^{a}	12.46 ± 0.41^{a}	124.54 ± 0.49^{a}	32.54 ± 0.55^{a}	365.65 ± 0.60^{a}	1243.27 ± 0.55^{a}	6.35 ± 0.30^{a}
J	315.63 ± 0.58^{b}	10.34 ± 0.27^{b}	115.54 ± 0.47^{b}	28.74 ± 0.23^{c}	334.13 ± 0.55^{b}	812.35 ± 0.28^{d}	6.13 ± 0.55^{b}

Means in the same column bearing different superscripts are significantly different ($p<0.05$)

Table 3a: Amino Acid Profile of the Breakfast Cereal Produced from Blends of Sorghum, Soybean, Bambara nut and defatted Groundnut (mg/100g)

Sample	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Trytophan	Valine
A	0.32 ± 0.12^{h}	0.86 ± 0.02^{g}	1.18 ± 0.11^{i}	0.87 ± 0.10^{g}	0.41 ± 0.04^{h}	0.81 ± 0.08^{f}	0.68 ± 0.10^{h}	0.20 ± 0.02^{i}	0.95 ± 0.09^{e}
B	0.38 ± 0.11^{g}	0.88 ± 0.05^{g}	1.28 ± 0.05^{h}	0.90 ± 0.11^{g}	0.46 ± 0.04^{g}	0.87 ± 0.08^{e}	0.69 ± 0.11^{h}	0.24 ± 0.04^{h}	0.97 ± 0.09^{e}
C	0.42 ± 0.12^{f}	1.38 ± 0.10^{f}	2.05 ± 0.10^{g}	1.33 ± 0.12^{f}	0.79 ± 0.07^{f}	0.88 ± 0.09^{e}	0.71 ± 0.07^{gh}	0.44 ± 0.07^{g}	1.43 ± 0.04^{abc}
D	0.44 ± 0.11^{f}	1.44 ± 0.11^{e}	2.14 ± 0.03^{f}	1.36 ± 0.12^{ef}	0.85 ± 0.08^{e}	0.91 ± 0.09^{e}	0.75 ± 0.10^{ef}	0.49 ± 0.04^{f}	1.46 ± 0.04^{a}
E	0.49 ± 0.12^{e}	1.46 ± 0.07^{e}	2.75 ± 0.12^{d}	1.38 ± 0.11^{e}	0.88 ± 0.08^{de}	0.96 ± 0.10^{d}	0.78 ± 0.11^{de}	0.54 ± 0.05^{e}	1.45 ± 0.08^{a}
F	0.58 ± 0.12^{d}	1.87 ± 0.50^{d}	2.34 ± 0.13^{e}	1.42 ± 0.09^{d}	0.92 ± 0.09^{d}	0.98 ± 0.09^{d}	0.82 ± 0.12^{d}	0.56 ± 0.05^{e}	1.38 ± 0.03^{d}
G	0.72 ± 0.15^{c}	1.96 ± 0.70^{c}	2.86 ± 0.11^{c}	2.05 ± 0.08^{c}	1.25 ± 0.10^{c}	1.05 ± 0.10^{c}	1.06 ± 0.08^{c}	0.88 ± 0.08^{d}	1.39 ± 0.04^{cd}
H	0.85 ± 0.17^{b}	1.98 ± 0.09^{c}	2.89 ± 0.11^{c}	2.08 ± 0.10^{bc}	1.27 ± 0.12^{c}	1.12 ± 0.06^{b}	1.19 ± 0.09^{b}	0.97 ± 0.09^{c}	1.41 ± 0.07^{bcd}
I	0.88 ± 0.11^{ab}	2.03 ± 0.11^{b}	3.65 ± 0.08^{b}	2.11 ± 0.11^{b}	1.34 ± 0.11^{b}	1.15 ± 0.07^{ab}	1.33 ± 0.08^{a}	1.06 ± 0.10^{b}	1.43 ± 0.05^{abc}
J	0.89 ± 0.12^{a}	2.10 ± 0.12^{a}	3.73 ± 0.07^{a}	2.32 ± 0.09^{a}	1.45 ± 0.13^{a}	1.17 ± 0.02^{a}	1.36 ± 0.05^{a}	1.19 ± 0.10^{a}	1.44 ± 0.06^{ab}

Means in the same column bearing different superscripts are significantly different ($p<0.05$)

Table 3b: Amino Acid Profile of the Breakfast Cereal Produced from Blends of Sorghum, Soybean, Bambara nut and defatted Groundnut (mg/100g)

Sample	Arginine	Alanine	Aspartate	Cysteine	Glutamate	Glycine	Proline	Serine	Tyrosine
A	0.41 ± 0.10^{e}	0.79 ± 0.07^{i}	1.32 ± 0.03^{d}	0.30 ± 0.03^{h}	1.45 ± 0.04^{f}	0.40 ± 0.05^{g}	0.24 ± 0.02^{g}	0.96 ± 0.09^{h}	0.64 ± 0.06^{h}
B	0.42 ± 0.12^{e}	0.82 ± 0.08^{gh}	1.43 ± 0.04^{c}	0.33 ± 0.03^{gh}	1.54 ± 0.05^{e}	0.43 ± 0.03^{g}	0.27 ± 0.02^{fg}	0.54 ± 0.05^{i}	0.69 ± 0.06^{g}
C	0.43 ± 0.11^{e}	0.84 ± 0.08^{g}	1.84 ± 0.08^{b}	0.35 ± 0.03^{fg}	2.29 ± 0.02^{d}	0.48 ± 0.04^{f}	0.30 ± 0.03^{f}	1.15 ± 0.09^{g}	0.75 ± 0.07^{f}
D	0.48 ± 0.12^{d}	0.88 ± 0.08^{f}	1.86 ± 0.07^{b}	0.39 ± 0.04^{ef}	2.33 ± 0.03^{d}	0.53 ± 0.05^{e}	0.42 ± 0.04^{e}	1.27 ± 0.11^{f}	0.90 ± 0.08^{e}
E	0.52 ± 0.09^{bcd}	0.90 ± 0.09^{ef}	1.88 ± 0.07^{b}	0.43 ± 0.05^{f}	2.39 ± 0.04^{c}	0.65 ± 0.06^{d}	0.53 ± 0.05^{d}	1.37 ± 0.11^{e}	1.18 ± 0.10^{d}
F	0.55 ± 0.07^{ab}	0.93 ± 0.09^{de}	1.93 ± 0.09^{a}	0.48 ± 0.04^{e}	2.48 ± 0.04^{ab}	0.68 ± 0.06^{d}	0.64 ± 0.07^{e}	1.43 ± 0.04^{d}	1.27 ± 0.11^{c}
G	0.56 ± 0.07^{ab}	0.95 ± 0.10^{cd}	0.97 ± 0.09^{e}	0.68 ± 0.06^{d}	2.45 ± 0.04^{b}	0.76 ± 0.07^{c}	0.66 ± 0.08^{c}	1.54 ± 0.05^{c}	1.29 ± 0.09^{bc}
H	0.50 ± 0.09^{cd}	0.98 ± 0.10^{bc}	1.00 ± 0.10^{e}	0.73 ± 0.07^{c}	2.50 ± 0.05^{a}	0.85 ± 0.08^{b}	0.62 ± 0.06^{c}	1.58 ± 0.05^{c}	1.29 ± 0.08^{bc}
I	0.54 ± 0.11^{abc}	0.99 ± 0.09^{b}	1.93 ± 0.09^{a}	0.79 ± 0.08^{b}	2.50 ± 0.05^{a}	0.92 ± 0.09^{a}	0.75 ± 0.06^{b}	1.67 ± 0.10^{b}	1.32 ± 0.10^{b}
J	0.58 ± 0.11^{a}	1.13 ± 0.07^{a}	1.96 ± 0.09^{a}	0.84 ± 0.08^{a}	2.50 ± 0.05^{a}	0.96 ± 0.09^{a}	0.80 ± 0.06^{a}	1.75 ± 0.10^{a}	1.38 ± 0.11^{a}

Means in the same column bearing different superscripts are significantly different ($p<0.05$)

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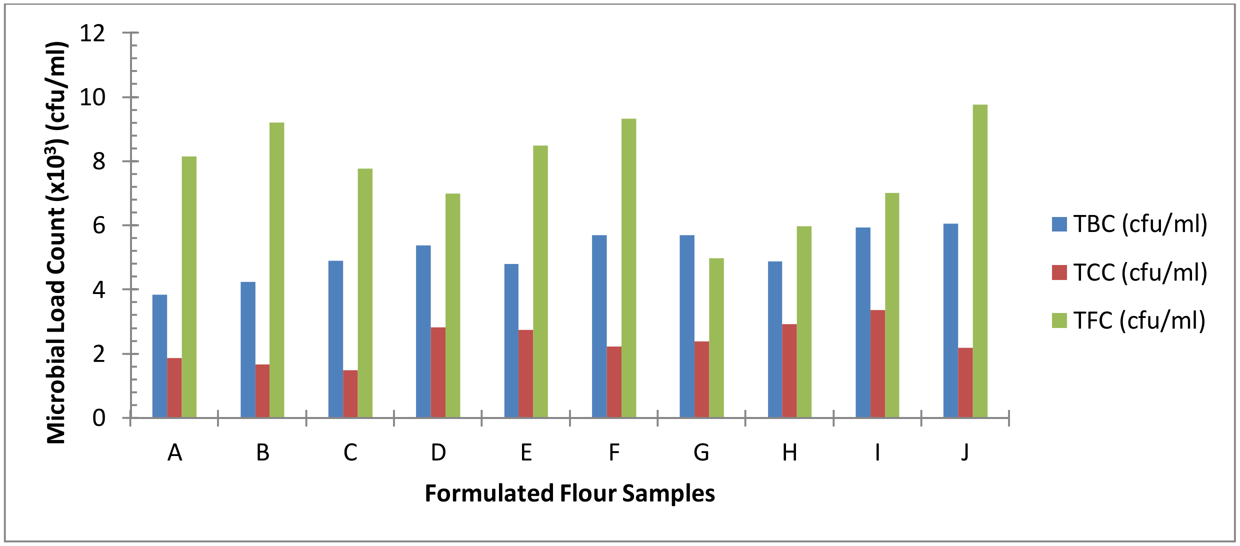

Figure 1: Microbiological Evaluation of Total Bacteria Count (TBC), Total Coliform Count (TCC), and Total Fungi Count (TFC)

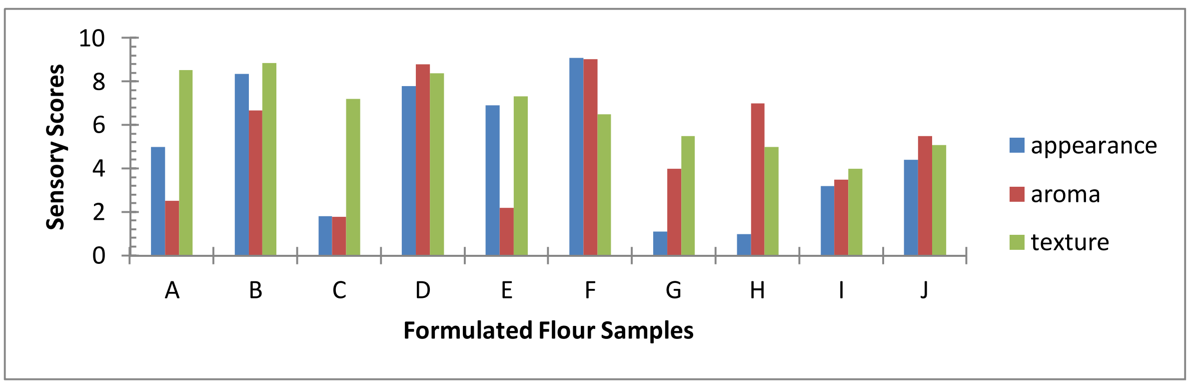

Figure 2: Sensory Evaluation of the Flours Formulated

Table 4: Effect of Storage Condition and Time on Peroxide Value of Formulated Flour Samples

Room Condition (°C)										
Storage Time (days)	A	B	C	D	E	F	G	H	I	J
0	5.55	5.51	5.45	5.25	5.24	5.25	5.25	5.25	6.25	5.42
2	5.53	5.52	5.25	5.27	5.25	5.27	5.26	5.26	5.25	5.52
4	5.54	5.52	4.25	5.29	5.26	5.31	5.32	5.27	6.26	5.82
6	5.59	5.42	5.35	5.31	5.35	5.35	5.35	5.32	5.30	5.23
8	5.54	5.55	4.77	5.44	5.30	5.36	5.37	5.33	4.31	5.33
10	5.44	5.77	4.09	5.33	5.00	5.38	5.38	5.34	5.36	5.53
Refrigeration Condition(°C)										
Storage Time (days)	A	B	C	D	E	F	G	H	I	J
0	5.50	5.61	5.59	5.60	5.58	5.52	5.53	5.52	6.55	5.24
2	5.52	5.73	5.60	5.52	5.50	5.72	5.65	5.63	5.88	5.25
4	5.63	5.75	4.55	5.60	5.57	5.77	5.99	5.72	6.06	5.99
6	5.71	5.83	5.72	5.75	5.65	5.65	5.65	5.24	5.09	5.00
8	5.75	5.95	4.75	5.69	5.68	5.64	5.77	5.37	4.99	5.99
10	5.80	5.88	4.88	5.62	5.81	5.40	5.82	5.39	5.91	5.00

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