**EVALUATION OF NUTRITIONAL AND ORGANOLEPTIC PROPERTIES OF BREAKFAST CEREALS FORMULATED FROM HUNGRY RICE, BAMBARA GROUNDNUT AND CARROT FLOUR BLENDS.**

**ABSTRACT**

This study was carried out to evaluate the nutrient composition and sensory properties of breakfast cereals produced from hungry rice, Bambara groundnut and carrot composite flours. Hungry rice grains, Bambara groundnut seeds and carrot fruits were separately processed into flours. The malted Bambara groundnut and carrot flours were used at vary replacement levels (5 – 30%) with malted hungry rice flour to produce breakfast cereals with the breakfast cereal produced from 100% malted hungry rice flour as control. The proximate, mineral and vitamin compositions and sensory properties of the breakfast cereal products were determined using standard methods. The proximate composition showed that the moisture, crude protein, fat, ash and crude fibre contents of the samples increased significantly (p<0.05) with increased substitution of Bambara and carrot flours with slight decrease in carbohydrate and energy contents. The mineral composition of the samples were 76.35-94.78mg/100g phosphorus, 113.34-126.02mg/100g calcium, 2.44-3.77mg/100g iron, 48.84-69.30mg/100g magnesium, 1.42-2.04mg/100g zinc and 36.10-67.30mg/100g potassium. Result showed that the mineral content of the samples increased with increased substitution of Bambara groundnut and carrot flours. The vitamin composition of the breakfast cereals also showed that the retinol (vitamin A), thiamine, riboflavin, niacin, cyanocobalamin and ascorbic acid contents of the samples increased with increased in the addition of Bambara groundnut and carrot flours. The sensory properties of the samples showed that the porridge made from the breakfast cereal substituted with 30% Bambara groundnut and 20% carrot flours was the most acceptable by the judges and also differed significantly (p<0.05) from both the control (Breakfast cereal made with 100% malted hungry rice flour) and other test samples in colour, taste, texture and aroma. The study, therefore, showed that the supplementation of hungry rice flour with Bambara groundnut and carrot flours at the levels of 25 to 30% could be used to produce nutritious and organoleptically acceptable breakfast cereal products.

Keywords: Breakfast cereals, enrichment, hungry rice flour, Bambara groundnut flour, carrot flour, nutrient composition, sensory properties.

**INTRODUCTION**

Breakfast cereal is a traditional breakfast food made from processed cereal grains. Breakfast cereals are economical, convenient and flavourable foods that are suitable for daily consumption by all age groups (Ishiwu *et al.,* 2019; Okoye *et al.,* 2023)

Breakfast cereals can be grouped into traditional hot cereals that need further heating or cooking before consumption or ready-to-eat cereals (RTEC) that are occasionally consumed with cream or milk (Encyclopedia, 2018). Ready-to-eat cereals are increasingly gaining acceptance in most developing countries, thereby displacing most traditional diets that serve as breakfast meals due to their convenience, nutritional values and employment demands (Usman, 2012).

The suitability of cereal, oil seed and legume blended meals for human consumption has been extensively reviewed (Radha *et al*., 2007).The general advice from the health experts is that there is need to consume a substantial well-balanced breakfast cereal product that delivers its energy slowly especially in the morning. Breakfast is also very important for children, adolescents and adults. Children who eat breakfast are more likely to have higher nutrients consumption, make more healthful food choices throughout the day and have a lower risk of overweight and obesity (Williams, 2014). Breakfast consumption has also been associated with reduction in weight gain and risk of chronic disease such as diabetes mellitus (Bi *et al*., 2015).

Studies have shown that the consumption of breakfast cereal is very beneficial (Willaims, 2014; Okoye *et al.,* 2023). The consumption of cereal foods such as breakfast cereals has become very popular in Nigeria especially among children. Children who eat breakfast cereals compared to other breakfast meals generally have healthier micro-nutrients profile, including higher daily consumption of vitamins A and D, the B-vitamins namely; thiamine (B1), riboflavin (B2), niacin (B3), pyridoxine (B6) and folate (B9) as well as minerals such as iron, magnesium and zinc (Bi *et al*., 2015). Breakfast cereal is the main contributor of dietary fibre in Nigeria, and studies have shown that breakfast cereals consumers have higher daily consumption of whole grains (Williams, 2014; Verma, 2015). Breakfast cereal consumption is also an important driver of milk consumption which facilitates higher consumption of calcium (Bi *et al*., 2015). In recent times, consumers have shown higher desire for processed food products that promote a balanced diet, aggregate nutritional value and bioactive compounds. Bioactive compounds are important to human health and nutrition, especially in the prevention of diseases.

Breakfast cereal is a processed food made from grains that is usually served with hot or cold milk and has to be eaten as a main course of the meal in the morning. Breakfast cereals are relatively shelf-stable, lightweight, convenient to distribute and store. They are made basically from corn, wheat, oats or rice mostly with added flavour and fortifying ingredients (Okoye *et al.,* 2023).

Cereals have been endorsed as the main source of breakfast’s carbohydrate and they also allow the consumers to vary their breakfast meal with different types of cereal-based products. However, breakfast cereals are nowadays available in so many formulations and have their consumption associated with the reduction in the risk of several chronic diseases in both adult and adolescents (Williams, 2014). Apart from being a good source of available carbohydrate, breakfast cereals can be also regarded as an important source of micronutrients (vitamins and minerals) and fibre, such as β-glucans, which play a key role in the prevention of cardiovascular diseases as well as in the improvement of appetite control and satiety (Rebello *et al.,* 2016; Pombo-Radrigues *et al.,* 2017).

Composite flours is a mixture of flours obtained from roots, cereals, legumes and fruits with or without the addition of wheat flour (Agu *et al.,* 2015). They are considered to be beneficial in developing and less developed countries because they help to reduce over dependence on imported wheat flour and encourage the utilization of non-wheat flours derived from locally grown food crops (Okoye *et al.,* 2013).

Hungry rice (*Digitaria exilis*) is one of the fastest growing cereal grains that is highly nutritious. It is a cereal crop of West African origin that has been cultivated in various parts of Nigeria, Sierra Leone, Ghana, Guinea Bissau, Senegal, Togo, Mali, Benin Republic and Cote’d’Ivore. This cereal crop has various local names such as *fundi*, *findi*, *acha*, or “hungry rice”. It is highly rich in carbohydrate and protein as well as sulphur containing essential amino acids such as methionine and cystine compared to legumes (Belton and Taylor, 2002; Vodouhé *et al.,* 2012). The minerals that are present in hungry rice are zinc, manganese, magnesium and potassium, while the vitamins found naturally in hungry rice are thiamine (vitamin B1) and riboflavin (vitamin B2) (Agu *et al.,* 2015).

Bambara groundnut (*Vigna subterranea* L. Verd *C*) is an indigenous underutilized legume that is now grown throughout the sub-Sahara African countries today (Mkandawire, 2007; Okonkwo and Opara, 2010; Bamshaiye *et al.,* 2011). It can grow under conditions that is unsuitable for groundnut. It is resistant to pests and diseases, and is also has high tolerance to drought and poor soil where many other leguminous crops cannot thrive. Bambara groundnut seeds are highly nutritious thereby making them relevant in the nutritional formulation of foods for people that cannot afford expensive protein sources, especially animal-based proteins (Ndidi *et al.,* 2014). The seeds have a higher content of high-quality amino acids such as arginine, leucine, valine, methionine and lysine when compared to cowpea, soybeans and groundnut which may potentially complement the deficient essential amino acid contents of cereal-based foods (Mazahib *et al.,* 2013).

Carrots (*Daucus carota* L.) are the most important crop of *Apiaceae* family. It is the root vegetable that is scattered all over the world and it is also regarded as good sources of fibre and bioactive compounds including β-carotene which manifests as a neutralizer of reactive species and also a precursor of retinol (vitamin A). It also contains vitamins such as vitamin K, ascorbic acid (C), thiamine, riboflavin, pyridoxine and folate which are necessary for the metabolism of carbohydrate and protein and maintenance of healthy growth (USDHHS, 2010; Dias, 2012a; Dias, 2012b). Thus, the combination of hungry rice, Bambara groundnut and carrot flours in the production of breakfast cereals would not only improve their nutrient contents but would also increase the quality of such food products. The objective of this study was to determine the nutrient composition and sensory properties of hungry rice-based breakfast cereals enriched with Bambara groundnut and carrot flours.

**MATERIALS AND METHODS**

**Procurement of Raw Materials**

Mature hungry rice (acha) (*Digitaria exilis*) grains, cream cultivar of Bambara groundnut (*Vigna subterranea* L.) seeds and carrots (*Daucus carota* L.) used for this study were purchased from *Ose Okwodu* Market, Onitsha, Anambra State, Nigeria. The chemicals used for the analyses of the samples were of the analytical grade.

**Preparation of Hungry Rice Flour**

The malted hungry rice flour was prepared according to the method described by Agu *et al*. (2015) with slight modifications. Three kilograms (3kg) of hungry rice grains was sorted to remove tiny stones, sands and other extraneous materials. The sorted grains were cleaned with tap water three times for 20 min and steeped in a plastic bowl with 2.5litres of tap water containing 5% of Sodium hypochlorite in the ratio of 1:3 for 24 h at room temperature (30±2°C) to sterilize the grains. After soaking, the grains were drained, rinsed repeatedly for five consecutive times with excess water and cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The sprouted grains were spread carefully on the wet jute bag and allowed to germinate in the germinating chamber at room temperature (30±2°C) and relative humidity of 95% for 96 h. During this period, the grains were sprinkled with water at intervals of 6 h to facilitate germination. Non-germinated grains were handpicked and discarded. The germinated grains were collected, spread on the trays and dried in a tray dryer (Model HR 6200, UK) at 60°C for 12 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. After drying, the rootlets of the malted hungry rice grains were removed by rubbing them in-between palms followed by winnowing. The dried malted hungry rice grains were milled in the hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an air tight plastic container, labelled and stored in a refrigerator until needed for further use.

**Preparation of Bambara Groundnut Flour**

The malted Bambara groundnut flour was prepared according to the method described by Okafor *et al*. (2014) with slight modifications. Two kilograms (2kg) of Bambara groundnut seeds was sorted to remove tiny stones, sands and other extraneous materials. The sorted seeds were cleaned and steeped in a plastic bowl with 3.5litres of tap water containing 5% of Sodium hypochlorite in the ratio of 1:3 for 24 h at room temperature (30±2°C) to sterilize the seeds. After soaking, the seeds were drained, rinsed repeatedly for five consecutive times with excess water and cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The sprouted seeds were spread carefully on the wet jute bag and allowed to germinate in the germinating chamber at room temperature (30±2°C) and relative humidity of 95% for 96 h. During this period, the seeds were sprinkled with water at intervals of 6 h to facilitate germination. Non-germinated seeds were handpicked and discarded. The germinated seeds were collected, spread on the trays and dried in a tray dryer (Model HR 6200, UK) at 60°C for 14 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. After drying, the rootlets of the malted Bambara groundnut seeds were removed along with the hulls by rubbing them in-between palms followed by winnowing. The dried malted Bambara groundnut seeds were milled in the hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an air tight plastic container, labelled and stored in a refrigerator until needed for further use.

**Preparation of Carrot Flour**

The carrot flour was prepared according to the method described by Aremu *et al*. (2011) with slight modifications. Three kilograms (3kg) of carrot fruits was manually sorted to remove dirt and other contaminants. The sorted carrots were cleaned with 2 liters of tap water and cut into smaller slices with a kitchen knife. The carrot slices were rinsed, placed into a stainless pot and blanched with 2.5liters of tap water at 80°C for 10 min on a hot plate. The blanched carrot slices were drained, rinsed, spread on the trays and dried in a tray dryer (Model HR 6200, UK) at 60°C for 10 h with occasional stirring of the slices at intervals of 30 min to ensure uniform drying. The dried slices were milled in the hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an air tight plastic container, labelled and stored in a refrigerator until needed for further use.

**Formulation of Composite Flours**

Malted hungry rice flour was mixed thoroughly with Bambara groundnut and carrot flours in different proportions of 100:0:0, 85:10:5, 80:15:5, 70:20:10, 60:25:15 and 50:30:20, respectively in a rotary mixer (Philips, type HR, 1500A, Holland) to obtain homogenous samples of composite flour. The composite flours produced were separately packaged in air tight plastic containers, labelled and stored in a refrigerator until needed for the preparation of breakfast cereals.

**Preparation of Shredded Breakfast Cereals**

The shredded breakfast cereals were prepared according to the method described by Ishiwu *et al.* (2019) with slight modifications. The shredded breakfast cereals were prepared by mixing the composite flours with small quantity of water, sugar and salt so as to have a binding effect. The mixture was heat treated individually by steaming for 10 min and then allowed to age at a temperature of 4°C for 6 h. The resultant doughs were separately cut into smaller sizes using a manually operated hand extruder. Thereafter, the dough pieces obtained were placed separately into flat greased baking trays and toasted in an electric oven (Gallenkamp oven, size one, England) at a temperature of 120°C for 1 h. After that, the samples were separately shredded using a manual wooden roller. The shredded breakfast cereals produced were allowed to cool at room temperature (30±2°C) and on cooling, they were packaged separately in air tight plastic containers, labelled and stored in a refrigerator until needed for analysis. Breakfast cereal made from 100% malted hungry rice flour was produced and used as control.

**Proximate Analysis**

The moisture content was determined by hot air oven drying of the samples at a constant temperature of 105 0C to constant weight according to the method of AOAC (2016). The ash, crude protein (N X 6.25), crude fibre and fat (Solvent extraction) were determined by the methods of AOAC (2016). The carbohydrate content was calculated by difference as 100% - % (Moisture + Crude Protein + Ash + Fat + Crude Fibre). The energy value was calculated by multiplying the percentage values of crude protein, fat and carbohydrate by the Atwater factors of 4, 9 and 4, respectively AOAC (2016). All determinations were carried out in triplicate samples and on dry weight basis.

**Mineral Analysis**

The mineral elements were extracted by dry ashing of the samples in a muffle furnace at a temperature of 550 0C to constant weight followed by the dissolution of the ash obtained from each sample in a volumetric flask by the addition of 50mL of de-ionized water and a few drops of Hydrochloric acid. The phosphorus, calcium and magnesium contents of the samples were determined on dry weight basis by the use of atomic absorption spectrophotometer. The potassium, iron and zinc contents were also determined using the Techcomp AA600 atomic absorption spectrophotometer and further confirmed by the use of a digital flame photometer according to the methods of AOAC (2016). All determinations were carried out in triplicate samples.

**Vitamin Analysis**

The thiamine, niacin and ascorbic acid contents of the samples were determined on dry weight basis by the use of atomic absorption spectrophotometer (Perkin-Elmer, Model 300, Norwalk, CT, USA) after extraction. The riboflavin and cyanocobalamin (Vitamin B12) contents were determined by the use of a digital fluorimeter. The retinol (Vitamin A) content was determined by the use of ultraviolet absorption spectrophotometer after extraction with chloroform. All determination followed the AOAC (2016) procedures and were carried out in triplicate samples.

**Sensory Evaluation**

The shredded breakfast cereals formulated from both the control and the composite flours were evaluated by a panel of twenty (20) semi-trained judges comprising of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The criteria for the selection of the panellists were based on their previous participation in similar sensory test and non allergic to any food. The panellists filled a consent form approved by the University Institutional Review Board and received instructions on how the sensory test would be conducted. The breakfast cereals were separately prepared into porridges by dispersing one hundred grams (100g) of each sample in fifty milliliters (50mL) of warm potable water. After that, the paste produced was poured into a stainless steel bowl with continuous stirring until it formed a stiff paste. Thereafter, two (2) teaspoonfuls of powdered milk were added to each sample and stirred repeatedly until the milk was evenly distributed. The samples were evaluated for the attributes of colour, taste, texture, aroma and overall acceptability using a nine point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Okaka, 2010). The sensory evaluation was carried out in the Food Processing and Preservation Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology (ESUT), Enugu, Nigeria. The laboratory was adequately lighted and free from distraction. The judges were arranged in such a way that they could not see the rating of each other. The samples were randomly coded and presented in white plastic plates to each panellist. Also, each panellist was provided with a plastic teaspoon, a cup of drinking water and unsalted crackers to rinse his/her mouth after tasting each sample to avoid residual effect. The sensory test was performed at 11.30am in the morning and the panellists evaluated and scored each sample based on their preference and acceptability of each of them. Expectoration cups with lids were provided to the judges who would not want to swallow the samples after tasting each of them.

**Statistical Analysis**

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Service Solution (SPSS, Version 21) software. Significant means were separated using the Tukey’s test at p<0.05.

**RESULTS AND DISCUSSION**

**Proximate Composition of Breakfast Cereal Samples**

The proximate composition of the breakfast cereals are presented in Table 1.

The moisture content of the breakfast cereals ranged from 6.18 to 7.31% with the control (Breakfast cereal made with 100% malted hungry rice flour) having the least moisture content (6.18%), while the sample enriched with 30% malted Bambara groundnut and 20% carrot flours had the highest value (7.31%). There were significant (p<0.05) differences in the moisture content of the samples. The variation in the moisture content observed could be attributed to differences in the moisture contents of the raw materials used in the formulation of the breakfast cereal products. The moisture content (6.18-7.31%) obtained in this study was lower than the values (4.71-9.88%) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals made from blends of *acha* and fermented soybean paste (*okara*). The low moisture content reported in this study is advantageous since the reduction in moisture content would reduce the growth and proliferation of spoilage and pathogenic micro-organisms especially bacteria and moulds, thereby resulting in the extension of the shelf life of the products with proper packaging and storage (Folake and Bolanle, 2006).

The protein content of the breakfast cereals ranged from 9.17 to 22.91%. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least value (9.17%) compared to the formulated breakfast cereal samples. The protein content of the samples was observed to increase with increased substitution of malted Bambara groundnut flour. This observation is in agreement with the reports that Bambara groundnut has the potential to improve the protein contents of breakfast cereals and other cereal-based products (Dikshit*et al*.*,* 2003; Maphosa and Jideani, 2007). The protein content (9.17-22.91%) obtained in this study was lower than the values (9.00-33.53%) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals made from blends of *acha* and fermented soybean paste (*okara*). The result showed that the increase in the addition of the Bambara groundnut flour resulted in corresponding increase in the protein content of the products. This clearly showed that the formulated breakfast cereals produced in this study would serve as a good source of protein, since plant proteins contribute reasonable amount of amino acids that are essential in human nutrition (Okaka *et al.,* 2008).

The fat content of the breakfast cereals ranged from 6.09 to 7.22%. There were significant (p<0.05) differences in the fat content of the samples. The fat content of the control (Breakfast cereal made with 100% malted hungry rice flour) was significantly (p<0.05) lower than the fat contents of all the formulated breakfast cereal samples. The sample supplemented with 30% Bambara groundnut and 20% carrot flours had the highest fat content compared to the control. The result is in agreement with the findings of Mbaeyi (2005) for breakfast cereals made from blends of sorghum and pigeon pea flour. The values (6.09-7.22%) obtained in this study were lower than the fat content (8.70-14.20%) reported by Agu *et al.* (2015) for breakfast cereals produced from malted *acha* and soybean flour blends. The fat contents of all the formulated breakfast cereal samples were generally higher than that of the control. The relatively low fat contents of the breakfast cereal products produced in this study would guarantee the extension of their shelf life by preventing the development of rancidity during the storage of the products.

The ash content of the breakfast cereals ranged from 3.20 to 4.86%. The control (Breakfast cereal made with 100% malted hungry rice flour) and the sample substituted with 30% Bambara groundnut and 20% carrot flours had the least (3.20%) and highest (4.86%) values, respectively. The ash content (3.20-4.86%) obtained in this study was higher than the values (1.36-2.44%) reported by Agunbiade and Ojezele (2010) for instant breakfast meals produced from maize, sorghum, soybean and African yam bean composite flours. The increase in the ash content observed in the formulated breakfast cereal samples could be attributed to high mineral content of Bambara groundnut and carrot flours used in the preparation of the breakfast cereal products. The increase in the ash content would also help in the metabolism of other macro-nutrients such as protein, fat and carbohydrate when consumed and utilized by the body (Agu *et al.,* 2015).

The crude fibre content of the breakfast cereals ranged from 3.37 to 4.89% with the control (Breakfast cereal made with 100% malted hungry rice flour) and the sample enriched with 30% Bambara groundnut and 20% carrot flours having the least (3.37%) and highest (4.89%) values, respectively. The crude fibre content of the samples was observed to increase with increase in the addition of malted Bambara groundnut and carrot flours and this is an indication that that Bambara groundnuts and carrots are rich sources of dietary fibre (Chau *et al.,* 2004; Afolabi *et al.,*2018). Fibre helps in the absorption of some micro-nutrients and also increases the utilization of nitrogen in the body (Okaka *et al.,* 2006). It also plays an important role in the removal of unwanted (waste) products from the body, thereby preventing constipation, colon cancer, heart failure and many other health disorders. The consumption of fibre-rich diets has been proved to reduce the cholesterol level, risk of coronary heart diseases and insulin responsiveness in the human body (Folake and Bolanle, 2006).

The carbohydrate content of the breakfast cereals ranged from 52.79to 71.97%. The control (Breakfast cereal made with 100% malted hungry rice flour) had the highest value 71.97%, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the least carbohydrate contents (52.79%). The result showed that there was a slight decrease in the carbohydrate content of the formulated breakfast cereal products with increased substitution of malted Bambara groundnut and carrot flours compared to the control. The values (52.79-71.97%) obtained in this study were higher than the carbohydrate content (59.99-62.31%) reported by Mbaeyi (2005) for breakfast cereals produced from blends of sorghum and pigeon pea flour.

The energy content of the breakfast cereals ranged from 367.86 to 379.43KJ/100g with the control (Breakfast cereal made with 100% malted hungry rice flour) and the sample substituted with 30% malted Bambara groundnut and 20% carrot flours having the highest (379.43KJ/100g) and lowest values (367.86KJ/100g), respectively. The energy value of the samples decreased significantly (p<0.05) with increased substitution of malted Bambara groundnut and carrot flours. Similar decrease in energy value has been reported by Mbaeyi (2005) for breakfast cereals made from blends of sorghum and pigeon pea flour. Energy value is an indication of the quantity of energy that is available in the food which can be supplied to the body for the basic body functions (Afolabi *et al.,* 2018).

The supplementation of hungry rice flour with malted Bambara groundnut and carrot flours in the production of breakfast cereals generally increased the protein, fat, ash and crude fibre contents of the products.

**Table 1: Proximate composition (%) of breakfast cereal samples**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Samples** |  **Moisture**  **Content** |  **Crude**  **Protein**  |  **Fat** |  **Ash** |  **Crude**  **Fibre** |  **Carbohydrate** |  **Energy** **Value** **(KJ/100g)** |
|  **A** | 6.18e ± 0.06 |  9.17f ± 0.09 |  6.09f ± 0.03 |  3.20f ± 0.02 |  3.37f ± 0.01 | 71.97a ± 0.06 | 379.43a ± 0.21 |
|  **B** | 6.25e ± 0.04 |  11.42e ± 0.14 |  6.33e ± 0.04 |  3.25e ± 0.03 |  3.64e ± 0.02 |  69.09b ± 0.03 | 379.07b ± 0.22 |
|  **C** | 6.62d ± 0.08 |  13.67d ± 0.10 |  6.64d ± 0.07 |  3.51d ± 0.04 |  3.85d ± 0.04 |  65.69c ± 0.06 | 377.28c ± 0.24 |
|  **D** | 6.87c ± 0.01 |  17.24c ± 0.12 |  6.82c ± 0.09 |  3.79c ± 0.05 |  4.17c ± 0.05 | 61.09d ± 0.07 | 374.76d ± 0.29 |
|  **E** | 7.17b ± 0.02 |  19.53b ± 0.11 |  7.06b ± 0.06 |  4.52b ± 0.06 |  4.48b ± 0.02 | 57.21e ± 0.09 | 370.58e ± 0.27 |
|  **F** | 7.31a ± 0.03 |  22.91a ± 0.70 |  7.22a ± 0.08 |  4.86a ± 0.07 |  4.89a± 0.04 | 52.79f ± 0.11 | 367.86f ± 0.23 |

Values are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Breakfast cereal produced from 100% malted hungry rice, B - Breakfast cereal produced from 85% malted hungry rice, 10% malted Bambara groundnut and 5% carrot flours, C - Breakfast cereal produced from 80% malted hungry rice, 15% malted Bambara groundnut and 5% carrot flours, D - Breakfast cereal produced from 70% malted hungry rice, 20% malted Bambara groundnut and 10% carrot flours, E - Breakfast cereal produced from 60% malted hungry rice, 25% malted Bambara groundnut and 15% carrot flours, F - Breakfast cereal produced from 50% malted hungry rice, 30% malted Bambara groundnut and 20% carrot flours.

**Mineral Composition of Breakfast Cereal Samples**

The mineral composition of the breakfast cereals are presented in Table 2.

The phosphorus content of the breakfast cereals ranged from 76.35 to 94.78mg/100g. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least (76.35mg/100g), while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest phosphorus content (94.48mg/100g). The values (76.35-94.78mg/100g) obtained in this study were lower than the phosphorus content (108.12-959.90mg/100g) reported by Mbaeyi (2005) for breakfast cereals produced from blends of pigeon pea and sorghum flour. The phosphorus content reported in this study for the formulated breakfast cereal products was lower than the US recommended dietary allowance (RDA) of 350-450mg/100g) for adults per day. Phosphorus is an important mineral that plays a significant role in the formation of Adenosine Triphosphate (ATP) in the body (Okaka *et al.,* 2006). It may also combine with calcium in the human body for the development of bones and teeth.

The calcium content of the breakfast cereals ranged from 113.34 to 126.02mg/100g. The control (Breakfast cereal made with 100% malted hungry rice flour) and the sample enriched with 30% malted Bambara groundnut and 20% carrot flours had the least (113.34mg/100g) and highest (126.02mg/100g) values, respectively. The values (113.34-126.02mg/100g) obtained in this study were lower than the calcium content (113-156mg/100g) reported by Agunbiade and Ojezele (2010) for instant breakfast cereals produced from maize, sorghum, soybean and African yam bean composite flours. The increase in calcium content observed in all the formulated breakfast cereal samples could be attributed to the substitution effect caused by high amounts of calcium in malted Bambara groundnut and carrot flours used for the formulation of the breakfast cereal products (Mbaeyi-Nwaoha and Uchendu, 2016, Ahmadu *et al.,* 2023). The calcium content of the formulated breakfast cereal products produced in this study was generally lower than the US recommended dietary allowance (RDA) of 1000mg/100g for adults per day. Calcium in conjunction with protein, phosphorus and magnesium are important for proper bone formation in infants and young children (Okaka *et al.,* 2006). Also, the combination of calcium with phosphorus and vitamin D helps in the prevention of rickets in children, osteomalacia (adult ricket) and osteoporosis (bone thinning) in older people (Verma, 2015).

The iron content of the breakfast cereals varied significantly (p<0.05) from each other. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least (2.44mg/100g) value, while the sample supplemented with 30% malted Bambara groundnut and 20% carrot flours had the highest value of 3.77mg/100g. The values (2.44-3.77mg/100g) obtained in this study were higher than the iron content ((0.45-1.10mg/100g) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of *acha* and fermented soybean paste (*okara*) but lower than the values (9.81-14.10mg/100g) reported by Usman (2012) for breakfast cereals produced from African yam bean, maize and defatted coconut flour blends. The iron content reported in this study for the formulated breakfast cereal products was generally lower than the US recommended dietary allowance (RDA) of 10-15mg/100g for adults per day. When foods that are rich in iron are eaten, they easily combine with protein and assist the protein to transport and release oxygen throughout the body system. Inadequate consumption of iron causes iron-deficiency anemia (IDA) which is very common around the world especially among women and children in developing countries. The symptoms of iron deficiency include body weakness, shortness of breath and fatigue (Okaka *et al.,* 2016; Verma, 2015).

The magnesium content of the breakfast cereals ranged from 48.84 to 69.30mg/100g. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least (48.84mg/100g) value, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest magnesium content (69.30mg/100g). The values (48.84-69.30mg/100g) obtained in this study were higher than the magnesium content (29.0-43.0mg/100g) reported by Usman (2012) for breakfast cereals produced from African yam bean, maize and defatted coconut flour blends. The magnesium content reported in this study for the formulated breakfast cereal products was lower than the US recommended dietary allowance (RDA) which is 350mg/100g for men and 280mg/100g for women, respectively. Magnesium in conjunction with calcium helps in the contraction of muscles and regulation of blood pressure. It also promotes proper function of lungs in human body. Magnesium is also needed for the synthesis of proteins, nerve transmission and maintenance of the immune system in the human body (Maphosa and Jideani, 2007; Afolabi *et al.,* 2018).

The zinc content of the breakfast cereals ranged from 1.42 to 2.04mg/100g with the control (Breakfast cereal made with 100% malted hungry rice flour) and the sample supplemented with 30% malted Bambara groundnut and 20% carrot flours having the least (1.42mg/100g) and highest (2.04mg/100g) values, respectively. The values (1.42-2.04mg/100g) obtained in this study were relatively higher than the zinc content (1.11-1.64mg/100g) reported by Agunbiade and Ojezele (2010) for instant breakfast cereals produced from maize, sorghum, soybean and African yam bean composite flours. The zinc content of the formulated breakfast cereal products produced in this study was lower than the US recommended dietary allowance (RDA) which is 15mg/100g for men and 12mg/100g for women, respectively. Zinc is a component of every living cell which assits in enzyme reactions and blood clotting in human body. It is also essential for vision, taste and healing of wounds. Zinc also supports normal growth and development especially during pregnancy, childhood and adolescence in the human body (Verma, 2015; Ahmadu *et al.,* 2023).

The potassium content of the breakfast cereals ranged from 36.10 to 67.30mg/100g. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least value (36.10mg/100g), while sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest potassium content (67.30mg/100g). The values (36.10-67.30mg/100g) obtained in this study were lower than the potassium content (107.02-328.0mg/100g) reported by Mbaeyi (2005) for breakfast cereals produced from blends of pigeon pea and sorghum flour but higher than the potassium content (88.0-191.0mg/100g) reported by Usman (2012) for breakfast cereals produced from blends of African yam bean, maize and defatted coconut flour. The potassium content of the formulated breakfast cereal products reported in this study was higher than the US recommended dietary allowance (RDA) which is 3.5mg/100g for both men and women, respectively. This showed that both the control and the formulated breakfast cereal samples produced in this study could be utilized as a good source of potassium by human subjects. Potassium is essential in blood clotting and contraction of muscles. It also helps in the maintenance of normal level of fluid inside the body cells (Aremu *et al.,* 2006; Verma, 2015).

The supplementation of malted hungry rice-based breakfast cereals with malted Bambara groundnut and carrot flours generally increased the mineral content of the products.

**Table 2: Mineral composition (mg/100g) of breakfast cereal samples**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Samples** |  **Phosphorus** |  **Calcium** |  **Iron** |  **Magnesium** |  **Zinc** |  **Potassium** |
|  **A** | 76.35e ± 0.01 |  113.34f ± 0.03 | 2.44e ± 0.03 | 48.84f ± 0.03 |  1.42f ± 0.08 | 36.10f ± 0.01 |
|  **B** |  77.92e ± 0.16 |  114.36e ± 0.03 | 2.87d ± 0.07 | 50.14e ± 0.14 |  1.56e ± 0.07 | 37.94e ± 0.68 |
|  **C** |  82.05d ± 0.75 |  117.47d ± 0.64 | 3.07c ± 0.05 | 55.82d ± 0.08 |  1.64d ± 0.05 | 42.21d ± 0.64 |
|  **D** |  84.95c ± 1.32 | 120.36c ± 0.03 | 3.40b ± 0.08 | 60.04c ± 0.11 |  1.72c ± 0.03 | 47.44c ± 0.78 |
|  **E** |  87.75b ± 0.66 |  123.15b ± 0.04 | 3.65a ± 0.04 | 64.54b ± 0.11 |  1.76b ± 0.04 | 55.54b ± 2.09 |
|  **F** |  94.78a ± 1.28 |  126.02a ± 0.14 | 3.77a ± 0.01 | 69.30a ± 0.45 |  2.04a ± 0.02 | 67.30a ± 0.03 |

Values are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Breakfast cereal produced from 100% malted hungry rice, B - Breakfast cereal produced from 85% malted hungry rice, 10% malted Bambara groundnut and 5% carrot flours, C - Breakfast cereal produced from 80% malted hungry rice, 15% malted Bambara groundnut and 5% carrot flours, D - Breakfast cereal produced from 70% malted hungry rice, 20% malted Bambara groundnut and 10% carrot flours, E - Breakfast cereal produced from 60% malted hungry rice, 25% malted Bambara groundnut and 15% carrot flours, F - Breakfast cereal produced from 50% malted hungry rice, 30% malted Bambara groundnut and 20% carrot flours.

**Vitamin Composition of Breakfast Cereal Samples**

The vitamin composition of the breakfast cereals are presented in Table 3.

The vitamin A (retinol) content of the breakfast cereals ranged from 2.47 to 3.11mg/100g. The result showed that the control (Breakfast cereal made with 100% malted hungry rice flour) had the least value of 2.47mg/100g, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest value (3.11mg/100g). The values (2.47-3.11mg/100g) obtained in this study were lower than the retinol content (11.13-83.05mg/100g) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of *acha* and fermented soybean paste (*okara*). The retinol content reported in this study for the formulated breakfast cereal products was higher than the US recommended dietary allowance (RDA) which is 0.9mg/100g for men and 0.7mg/100g for women, respectively. This is a clear indication that both the control and the formulated breakfast cereal products developed in this study would serve as a good source of retinol (Vitamin A) for humans. Retinol (vitamin A) is a fat soluble vitamin which plays an important role in the maintenance of good vision (Okaka *et al.,* 2006). It is also an important antioxidant which plays a major role in fighting against diseases like glycoma, diabetes mellitus and cancer in human body (Verma, 2015).

The thiamine content of the breakfast cereals ranged from 3.03 to 3.33mg/100g with the control (Breakfast cereal made with 100% malted hungry rice flour) and the sample supplemented with 30% malted Bambara groundnut and 20% carrot flours having the least (3.03mg/100g) and highest (3.33mg/100g) values, respectively. The values (3.03-3.33mg/100g) obtained in this study were higher than the thiamine content (0.09-0.31mg/100g) reported by Mbaeyi (2005) for breakfast cereals produced from blends of pigeon pea and sorghum flour. The thiamine content of the formulated breakfast cereal products produced in this study was higher than the US recommended dietary allowance (RDA) of 1.5mg/100g per day. This showed that all the breakfast cereals formulated in this study could be utilized by humans as a good source of thiamine. Thiamine plays an important role as a co-enzyme in energy metabolism. It also acts as a coenzyme in the metabolism of fats, proteins, carbohydrates and other nutrients in the human body. It equally helps in the treatment of *beriberi* and maintenance of healthy mental attitude in young children and adolescents (Okaka *et al.,* 2006; Williams, 2014).

The riboflavin content of the breakfast cereals ranged from 4.35 to 5.27mg/100g. The control (Breakfast cereal made with 100% malted hungry rice flour) had the least 4.35mg/100g value, while the breakfast cereal substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest value (5.27mg/100g). The values (4.35-5.27mg/100g) obtained in this study were higher than riboflavin content (0.32-0.43mg/100g) reported by Usman (2012) for breakfast cereals produced from blends of African yam bean, maize and defatted coconut flour. The riboflavin content reported in this study for the formulated breakfast cereal products was higher than the US recommended dietary allowance (RDA) of 1.7mg/100g. This is an indication that all the breakfast cereal products formulated in this study have the potentials to be utilized as a good source of riboflavin by humans. Riboflavin acts as a coenzyme in the metabolism of fats, proteins, carbohydrates and other nutrients. It also helps in fatty acid reduction and catabolism of nutrients in the liver. It is equally necessary for cell respiration and formation of red blood cells in the human body (Sreerama *et al.,* 2012; Okoye *et al.,* 2025).

The niacin content of the breakfast cereals ranged from 4.34 to 4.62mg/100g. The result showed that the niacin content of the samples increased significantly (p<0.05) with increased substitution of malted Bambara groundnut and carrot flours. The values (4.34-4.62mg/100g) obtained in this study were higher than the niacin content (0.53-2.85mg/100g) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of *acha* and fermented soybean paste (*okara*). The niacin content reported in this study for the formulated breakfast cereal products was lower than the US recommended dietary allowance (RDA) which is 16mg/100g for men and 14mg/100g for women, respectively. Niacin plays an important role in energy transfer reactions in the metabolism of glucose, alcohol and fat. It also has specific effect on the growth. It equally plays an important role in reducing the levels of blood cholesterol in the human body (Verma, 2015; Ahmadu *et al.,* 2023).

The vitamin B12 (cyanocobalamin) content of the breakfast cereals ranged from 3.10 to 4.16mg/100g with the control (Breakfast cereal made with 100% malted hungry rice flour) and the sample supplemented with 30% malted Bambara groundnut and 20% carrot flours having the least (3.10mg/100g) and highest (4.16mg/100g) values, respectively. The values (3.10-4.16mg/100g) obtained in this study were higher than the cyanocobalamin content (0.74-1.01mg/100g) reported by Usman (2012) for breakfast cereals produced from blends of African yam bean, maize and defatted coconut flour. The cyanocobalamin content reported for the formulated breakfast cereal products was higher than the US recommended dietary allowance (RDA) of 2.0mg/100g. This is clear indication that the products were generally high in cyanocobalamih content and could be also consumed as a potential source of this vitamin by human subjects. Cyanocobalamin is important in the maintenance of the healthy metabolism, blood cells and nerves in the body (Okaka *et al.,* 2006).

The vitamin C (ascorbic acid) content of the breakfast cereals ranged from 3.74 to 4.77mg/100g. The result showed that the control (Breakfast cereal made with 100% malted hungry rice flour) had the least value (3.74mg/100g), while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest ascorbic acid content. The increase in ascorbic acid content could be due to differences in the composition of the raw materials used for the formulation of the breakfast cereal products (Ahmadu *et al.,* 2023). The values (3.74-4.77mg/100g) obtained in this study were higher than the ascorbic acid content (1.70-2.65mg/100g) reported by Usman (2012) for breakfast cereals produced from blends of African yam bean, maize and defatted coconut flour. The ascorbic acid content reported in this study for the formulated breakfast cereal products was lower than the US recommended dietary allowance (RDA) of 30-60mg/100g for men, women and children. Ascorbic acid is important in the prevention of scurvy and development of healthy immune system in infants, young children and adults. Vitamin C is also used as an antioxidant which helps in the prevention of certain diseases such as cancer and diabetes mellitus in the human body (Ayogu *et al.,* 2017; Okoye *et al. ,*2025).

The substitution of malted *acha*-based breakfast cereals with malted Bambara groundnut and carrot flours greatly increased the vitamin content of the products.

**Table 3: Vitamin composition (mg/100g) of breakfast cereal samples**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Samples** |  **Retinol****(Vitamin A)** |  **Thiamine** |  **Riboflavin** |  **Niacin** |  **Cyanocobalamin** |  **Ascorbic acid** |
|  **A** |  2.47e ± 0.02 |  3.03f ± 0.07 | 4.35f ± 0.03 | 4.34e ± 0.03 | 3.10e ± 0.01 | 3.74f ± 0.03 |
|  **B** |  2.59d ± 0.04 |  3.07e ± 0.05 | 4.55e ± 0.03 | 4.36e ± 0.03 | 3.44d ± 0.03 | 3.83e ± 0.02 |
|  **C** |  2.70c ± 0.03 |  3.11d ± 0.08 | 4.72d ± 0.04 | 4.42d ± 0.04 | 3.71c ± 0.07 | 4.01d ± 0.05 |
|  **D** |  2.75c ± 0.04 |  3.17c ± 0.04 | 4.90c ± 0.02 | 4.48c ± 0.05 | 3.94b ± 0.07 | 4.25c ± 0.04 |
|  **E** |  2.88b ± 0.05 |  3.23b ± 0.05 | 5.15b ± 0.04 | 4.53b ± 0.07 | 4.04b ± 0.03 | 4.45b ± 0.04 |
|  **F** |  3.11a ± 0.06 |  3.33a ± 0.04 | 5.27a ± 0.05 | 4.62a ± 0.08 | 4.16a ± 0.02 | 4.77a ± 0.05 |

 Values are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Breakfast cereal produced from 100% malted hungry rice, B - Breakfast cereal produced from 85% malted hungry rice, 10% malted Bambara groundnut and 5% carrot flours, C - Breakfast cereal produced from 80% malted hungry rice, 15% malted Bambara groundnut and 5% carrot flours, D - Breakfast cereal produced from 70% malted hungry rice, 20% malted Bambara groundnut and 10% carrot flours, E - Breakfast cereal produced from 60% malted hungry rice, 25% malted Bambara groundnut and 15% carrot flours, F - Breakfast cereal produced from 50% malted hungry rice, 30% malted Bambara groundnut and 20% carrot flours.

**Sensory Properties of Breakfast Cereal Samples**

The sensory properties of the breakfast cereals are presented in Table 4.

The score for the colour of the breakfast cereal samples ranged from 4.55 to 7.11. The result showed that the score for the colour of the control (Breakfast cereal made with 100% malted hungry rice flour) was 4.55, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest value for colour (7.11). The values (4.55-7.11) obtained in this study were lower than the colour score (7.25-7.95) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of *acha* and fermented soybean paste (*okara*). The colour change observed could be due to increase in the addition of malted Bambara groundnut and carrot flours to *acha* flour in the formulation of the breakfast cereals. Colour appeared to be a very important parameter used by the consumers to indicate their preference for a food product.

The score for the taste of the breakfast cereal samples ranged from 4.66 to 5.88. The result showed that the score for the taste of the breakfast cereal supplemented with 25% malted Bambara groundnut and 15% carrot flour was 4.66, while the breakfast cereal product substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest value (5.88) compared to the control sample (Breakfast cereal made with 100% matted hungry rice flour) which had the taste score of 4.88. The values (4.66-5.88) obtained in this study were lower than the taste score (7.40-7.90) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of *acha* and fermented soybean paste (*okara*). Taste is an important sensory parameter used for the assessment of food acceptability. It also assists the taste organ to evaluate the palatability and assimilation capacity of a food product for metabolism by the body when ingested (Okaka, 2010).

The score for the texture of the breakfast cereal samples ranged from 4.66 to 6.77. The result showed that the score for the texture of the control (Breakfast cereal made with 100% malted hungry rice flour) was 4.66, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest score for texture (6.77). The values (4.66-6.77) obtained in this study were lower than the texture score (7.05-7.60) reported by Ahmadu *et al.* 2013) for breakfast cereals produced from millet flour supplemented with soybean and date fruit flours. The texture of food plays a very important role in the sensory assessment. The texture of a food product has the ability to reveal any deviation from an expected attribute for that particular food under investigation.

The score for the aroma of the breakfast cereal samples ranged from 4.77 to 5.86. The result showed that the score for the aroma of the sample substituted with 10% malted Bambara groundnut and 5% carrot flours was 4.77, while the sample substituted with 30% malted Bambara groundnut and 20% carrot flours had the highest score for aroma (5.86) compared to the control which had the aroma score of 5.44. The values (4.77-5.86) obtained in this study were lower than the aroma score (7.55-8.60) reported by Ahmadu *et al.* (2023) for breakfast cereals produced from millet flour supplemented with soybean and date fruit flours. Aroma is an important sensory attribute of food which contributes to the acceptability and palatability of a food product when consumed.

 The score for the overall acceptability of the breakfast cereal samples ranged from 4.66 to 6.66. The result showed that the score for the overall acceptability of the sample substituted with 10% malted Bambara groundnut and 5% carrot flours was 4.66, while the formulated breakfast cereal supplemented with 30% malted Bambara groundnut and 20% carrot flours had the highest score for overall acceptability (6.66). The values (4.66-6.66) obtained in this study were lower than the overall acceptability score (6.85-7.90) reported by Ishiwu *et al.* (2019) for breakfast cereals produced from blends of African yam bean and corn flour. The overall acceptability is an important sensory attribute used for assessing the acceptability of a food product in terms of colour, taste, texture, aroma other sensory attributes after sensory evaluation. The consumer acceptability of a food is known as the overall or general acceptability of that particular food product (Okaka, 2010).

Generally, the supplementation of malted hungry rice flour with 30% malted Bambara groundnut and 20% carrot flours could be used to produce organoleptically acceptable breakfast cereal products compared to the breakfast cereal produced from 100% malted hungry rice which served as control.

**Table 4: Sensory properties of breakfast cereal samples**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Samples** |  **Colour** |  **Taste** |  **Texture** |  **Aroma** |  **Overall**  **Acceptability** |
|  **A** | 4.55f ± 2.30 | 4.88d ± 2.09 |  4.66f ± 2.18 |  5.44b ± 1.33 |  5.11d ± 2.26 |
|  **B** | 4.66e ± 2.35 | 4.88d ± 2.03 |  5.55c ± 1.11 |  4.77e ± 1.48 |  4.66e ± 1.80 |
|  **C** | 5.55c ± 1.51 | 5.55c ± 2.13 |  5.66b ± 1.73 |  5.00d ± 1.73 |  5.44b ± 1.81 |
|  **D** | 5.11d ± 1.27 | 5.66b ± 2.06 |  5.22d ± 1.30 |  5.11c ± 2.15 |  5.11d ± 1.90 |
|  **E** | 5.88b ± 1.96 | 4.66e ± 2.06 |  5.00e ± 2.06 |  5.44b ± 1.24 |  5.22c± 1.86 |
|  **F** | 7.11a ± 1.27 | 5.88a ± 1.69 |  6.77a ± 1.72 |  5.86a ± 2.40 |  6.66a ± 1.00 |

Values are mean ± standard deviation of twenty (20) semi-trained judges. Means in the same column bearing different superscripts are significantly (p<0.05) different from each other.

A - Breakfast cereal produced from 100% malted hungry rice, B - Breakfast cereal produced from 85% malted hungry rice, 10% malted Bambara groundnut and 5% carrot flours, C - Breakfast cereal produced from 80% malted hungry rice, 15% malted Bambara groundnut and 5% carrot flours, D - Breakfast cereal produced from 70% malted hungry rice, 20% malted Bambara groundnut and 10% carrot flours, E - Breakfast cereal produced from 60% malted hungry rice, 25% malted Bambara groundnut and 15% carrot flours, F - Breakfast cereal produced from 50% malted hungry rice, 30% malted Bambara groundnut and 20% carrot flours.

**CONCLUSION**

The study showed that the increase in the addition of malted Bambara groundnut and carrot flours to malted hungry rice flour in the preparation of breakfast cereal products resulted in corresponding increase in crude protein, fat, ash, crude fibre, phosphorus, calcium, iron, magnesium, zinc, potassium, vitamin A thiamine, riboflavin, niacin, cyanocobalamin and ascorbic acid contents of the formulated breakfast cereal samples compared to the control (Breakfast made with 100% malted hungry rice flour). The sensory properties showed that the breakfast cereal substituted with (30%) malted Bambara groundnut and (20%) carrot flours was the most acceptable by the judges compared to the control and other formulated samples.

In addition, the substitution of hungry rice flour with Bambara groundnut and carrot flours at varying replacement levels (5-30%) in the production of breakfast cereals could be used to produce nutritious and organoleptically acceptable products. Moveover, the commercialization of these novel food products could be of great benefits to the food processing industries which would in turn help boost the economy of Nigeria and other developing countries where these nutrient dense food crops are relatively cheap and available.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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