Original Research Article

Production and Evaluation of Breakfast Cereals from Flour Blends of Maize (*Zea mays*) and Jackfruit (*Artocarpus heterophyllus Lam.*) Seeds.

ABSTRACT

Aim: Jackfruit is an underutilized tropical and subtropical fruit that is consistently lost to wastages and postharvest losses, neither has it gained substantial research attention. Therefore, the study is aimed at the production and evaluation of breakfast cereals formulated from composite blends of maize flour and jackfruit seed flour.

Study design: This study was made to fit into a one way Analysis of Variance.

Place and Duration of Study: The research was carried out at the Department of Food Science and Technology laboratory,, Federal University of Technology, Owerri, Nigeria, between February 2018 and October 2018.

Methodology: Flaked breakfast cereals were produced from blends of different ratios of Maize flour to Jackfruit seed flour. The formulated breakfast cereal products were evaluated for proximate composition, functional properties, anti-nutritional properties, mineral content and sensory properties.

Results: The mineral content of the formulated breakfast cereals showed significant difference ($P<0.05$) in Ca(156.23-184.14mg/100g), Mg (179.28-207.81mg/100g), K(70.62-78.53mg/100g), Fe(4.01-5.46mg/100g), Na(9.44-10.66mg/100g), Zn(1.72-2.29mg/100g) and P(10.38-13.62mg/100g). The moisture content (3.83 - 4.14%) of the formulated products was acceptable for shelf life extension of the flaked breakfast cereal products. Protein, ash, crude fiber and fat content of the formulated breakfast cereal products increased with increased addition of jackfruit seed flour while the carbohydrate and energy value of the formulated products decreased with increased addition of jackfruit seed flour. Bulk density and water absorption capacity of the formulated products increased with increased addition of jackfruit seed flour while oil absorption capacity, foam capacity, viscosity and gelation capacity decreased with increased addition of jackfruit seed flour. Processing method significantly reduced the relatively high level of anti-nutrients associated with Jackfruit seed. Panelist preference increased with a corresponding decrease in jackfruit seed flour addition.

Conclusion: Utilization of jackfruit in food product development may solve the problem of wastage and postharvest losses associated with this fruit.

Keywords: breakfast cereal, composite flour, flour blend, jackfruit, maize

1. INTRODUCTION

Breakfast is the first meal of the day [1]. It is a compound of “break” and “fast”, which literally means “breaking the fast” from the last meal or snack from the previous day. Nutritional experts have referred to breakfast as the most important meal of the day, citing studies that found people who skip breakfast to likely have problem with constipation, metabolism and weight [2]. Researchers who have studied the benefits of having breakfast reported that its merits is mainly due to the protein consumed from the breakfast meal. Ensminger [3] reported that high protein breakfast meal were found to be better than low protein breakfast meal as it helps to maintain a normal blood sugar level between mid-morning and lunch.

Breakfast meal vary widely in different cultures around the world. It often includes a carbohydrate source such as cereals, fruits and/or vegetables and sometimes beverages. In developing countries, particularly Sub-Sahara Africa, breakfast meals for both adults and infants are based on local staple diet made from cereals, legumes and tubers. However, the most widely eaten breakfast foods are produced from cereals [4].

Breakfast cereal can be defined as a dry cereal which has been processed into different forms by soaking, grinding, rolling, flaking or shredding before roasting or puffing. In Nigeria, two categories of breakfast cereals are popular, namely the powdered mix which are boiled or formed into gruel and served hot such as “akamu” (corn starch gruel), oat, custard and the manufactured ready-to-eat flaked cereals that can be eaten as it is or mixed with milk. These two categories of breakfast cereals together with bread are gradually displacing most traditional diets and staples that were served and consumed earlier as breakfast due to nutritional value & awareness, improved convenience and economic status.

Maize (*Zea mays*) is a major raw material for production of breakfast cereals. It is the third most important crop after wheat and rice and is grown in more countries than any other crop in the world [5, 6]. It is cultivated virtually in all parts of the world except Antarctica [6]. Though maize is an important crop for human food such as “agidi” and most breakfast meals, it is also an important raw material for industrial use as it is presently utilized for animal feed and as adjunct in brewing industries, thereby placing serious burden on the grain. It is worthy to note that this challenge has necessitated processors and researchers towards finding another food crop that can be used to substitute some fractions of the maize flour in breakfast meal and other food formulations.

However, jackfruit is (*Artocarpus heterophyllus Lam*.) is a plant crop that grows in tropical and subtropical regions throughout the world. It can be used as vegetable and consumed as fruit when ripe. Jackfruit is an extremely versatile and sweet tasting fruit that possess high nutritional value as it contains up to 79% carbohydrate, 13% protein, 3.2% fiber, vitamins and minerals [7] and also has a very short shelf life. Jackfruit is an underutilized fruit that is mainly consumed as fruit, and as a result is being wasted to economic and postharvest losses due to lack of industrial utilization.

The production of flaked breakfast cereal from blends of Maize and Jackfruit seed flours is hoped to aid the utilization of the jackfruit seeds thereby minimizing the wastages and postharvest losses of Jackfruit seed as well as creating variety in breakfast cereal product. In addition, jackfruit seeds are known to contain up to 300mg/100g of calcium, 338mg/100g of magnesium, 147mg/100g of potassium and only 6.0mg/100g of sodium [8]; thus the blends will improve the supply of these minerals in the diet and aid low sodium intake. Therefore the aim of this research work is to produce and evaluate breakfast cereals from flour blends of maize and jackfruit seeds.

2. MATERIALS AND METHODS

2.1 Materials Procurement

The Jackfruit (*Artocarpus heterophyllus*) seeds used for this study were plucked from the premises of Federal University of Technology Owerri, (FUTO) campus was identified in Department of Crop Science, Federal University of Technology Owerri (FUTO). Wholesome Maize grain (*Zea mays*) yellow variety were purchased from Ekeonunwa market in Owerri municipal, Imo State, Nigeria. Other ingredients such as sugar and salt were also purchased from Ekeonunwa market in Owerri municipal.

The processing of samples and experiment were carried out using the facilities available at the laboratory of Department of Food Science and Technology, Federal University of Technology, Owerri, Nigeria.

2.2 Sample Preparation

The Jackfruit was washed with clean water, sliced open and manually deseeded. The Jackfruit seeds were cleaned manually and the white arils (seed coat) were peeled off. The seeds were soaked in water for 24 hours to remove the thin brown spermoderm that covers the cotyledon. The wholesome maize grains were properly sorted and cleaned to remove stones, dirt, chaff, defected grains and other extraneous materials before they were used for further processing.

<u>2.2.1 Production of Jackfruit seed flour</u>

The peeled Jackfruit seed's cotyledons were steamed for 20 minutes and drained off water. The steamed cotyledons were allowed to cool at room temperature and sliced into thin chips. The sliced cotyledons were dried at 80^{0}C in an oven (Genlab oven-mino/50) to a constant moisture content. The dried chips were milled with an attrition milling machine then sieved to obtain the flour and packaged.

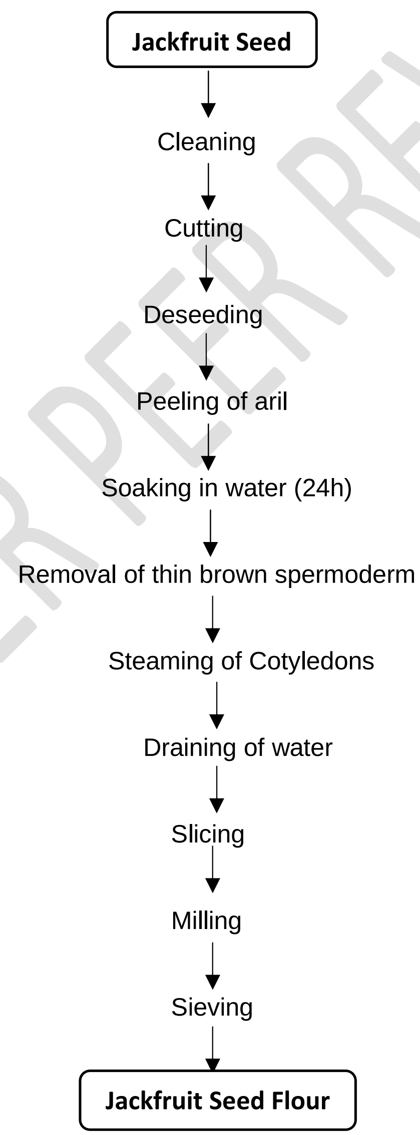

Figure 1: Flow diagram for the production of jackfruit seed flour

2.2.2 Production of Maize flour

The method of Ihekoronye and Ngoddy [9] was used but with slight modification. 5kg of cleaned yellow maize was milled into flour with an attrition milling machine and then packaged for further analysis.

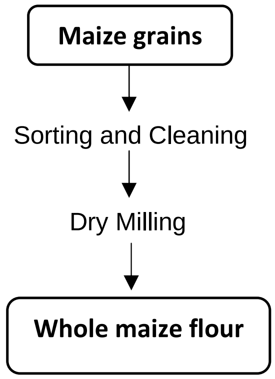

Figure 2: Flow diagram for the production of whole maize flour

2.3 Formulation of Composite Flour

Composite flour was formulated by mixing Jackfruit seed flour (JSF) and Maize flour (MF). Six samples of breakfast cereals blends were generated by mixing the composite flour of Jackfruit seed flour (JSF) and maize flour (MF) in the ratio of (100:0,90:10,80:20,70:30,60:40, 50:50). A control sample was produced from 100% maize.

Table 1: Composites flour formulation for breakfast cereals made from blends of Jackfruit Seed and Maize Flours

Sample	Sample Code	Proportion	Percentage
AAA	MF	100:0	100% MF
ABD	MF + JSF	90:10	90% MF + 10% JSF
ABC	MF + JSF	80:20	80% MF + 20% JSF
ABB	MF + JSF	70:30	70% MF + 30% JSF
ABA	MF + JSF	60:40	60% MF + 40% JSF
ABE	MF + JSF	50:50	50% MF + 50% JSF

MF = Maize Flour, JSF = Jackfruit Seed Flour

Table 2: Ingredient combination for Breakfast cereal from blends of MF and JSF per 100g

Ingredient	AAA	ABD	ABC	ABB	ABA	ABE
Maize flour	100	90	80	70	60	50
Jackfruit seed flour	-	10	20	30	40	50
Sugar	5	5	5	5	5	5
Salt	1	1	1	1	1	1


Plate 1: Jackfruit


Plate 2: Dried Jackfruit seed


Plate 3: Jackfruit Seed Flour


Plate 4: Maize Flour

2.4 Breakfast Cereal production

The breakfast cereal was prepared by mixing the formulated composite flours (JSF and MF) with sugar, salt and water. The resultant batter was poured thinly on a cleaned flat greased stainless tray and placed in the oven (gas oven) until a semi dried product was obtained. The semi dried products were cut with a sharp knife, placed back into the oven for further drying and toasting at 280^{o}C. The dried products were cooled and packaged in polythene bag.

Plate 5: Formulated Breakfast Cereals

2.5 Analysis of Samples

2.5.1 Proximate Composition

The method of A.O.A.C. [10] was used for this determination of moisture content, fat, crude protein, crude fibre and ash determinations, while Carbohydrate was calculated by difference.

2.5.2 Determination of Total Energy

The total energy was determined by the method described by Kanu *et al.* [11].

2.5.3 Determination of Mineral Content

Formulated samples were analyzed for mineral composition by digesting the samples in HCl according to the method of AOAC [12] using an Atomic Absorption Spectrophotometer (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Nowalk, Connecticut, USA).

2.5.4 Determination of Anti-Nutritional Factors

2.5.4.1 Determination of Phytate/Phytic Acid

The Phytate determination as described by Thompson and Erdman [13].

2.5.4.2 Determination of Tannin

The Folin-Denis colorimetric method as described by Kirk and Sawyer [14] was used for the determination of tannin content in the samples.

2.5.4.3 Determination of Alkaloid

Alkaloids was determined using the alkaline precipitation method as described by Harbone [15].

2.5.4.4 Saponin Determination

Saponin determination was carried out according to the method of AOAC [12].

2.5.4.5 Determination of Trypsin Inhibitor Activity

This was carried out according to the method described by Kakade *et al*., [16].

2.5.5 Determination of Functional Properties

The bulk density, foam capacity, viscosity, gelation capacity, water and oil absorption capacity were determined for each of the formulated sample using the method described by Onwuka [17].

2.6 Sensory Evaluation

The formulated samples were evaluated by 20 members of panelists. The panelists evaluated each of the samples for colour, crumb texture, crust texture, taste, aroma, and general acceptability. A nine (9) point hedonic scale as described by Ihekoronye and Ngoddy [9] was used to carry out the sensory evaluation.

9 = Like extremely;
8 = Like very much;
7 = Like moderately;
6 = Like slightly;
5 = Neither like nor dislike;
4 = Dislike slightly;
3 = Dislike moderately;
2 = Dislike very much;
1 = Dislike extremely.

2.7 Statistical Analysis

The data generated was subjected to one way analysis of variance using Microsoft Excel 2007 software and means were separated using Fisher's Least Significant Difference (LSD) at $P<0.05$.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Breakfast Cereals

The mean values of the proximate composition of the formulated samples are as shown in Table 3. The moisture content of the breakfast cereal samples ranged from 3.62% to 4.14%. Some significant ($P < 0.05$) differences existed among the samples except sample AAA and ABB with 3.86±0.021 and 3.83±0.023 respectively. This result was in agreement with the values obtained by Usman [18] for a breakfast cereal made from African Yam Bean (AYB), Maize and defatted coconut flour. The generally low moisture contents observed in the formulated breakfast cereal samples maybe beneficial in extending the shelf life of the product with proper packaging and storage.

The protein content of the formulated breakfast cereals ranged from 4.19% to 12.15%. Higher values of 15.68% to 18.26% protein content were recorded for a breakfast cereal made from a composite of AYB, Maize and defatted coconut flour [18] and for a breakfast cereal made from treated Pigeon Pea and sorghum with protein content of 13.53% to 15.05% [19]. The variation in the protein content is because of differences in raw material used in the formulation of the breakfast cereals. Sample AAA (100% Maize flour) recorded the least protein content of 4.19% while the highest protein content (12.15%) was recorded by ABE (50% Maize flour: 50% Jackfruit seed flour). There was an increase in the protein content with addition of Jackfruit seed flour (JSF) in the maize flour. Jackfruit seed has been reported to contain about 13% protein [8]. The generally high level of protein, certainly demonstrates the effect of supplementation of maize flour with Jackfruit seed flour for breakfast cereal production.

The fat contents of the formulated samples were generally low with values ranging from 1.1 to 1.48%. These range of values were lower compared to the values of 1.84 to 2.02% reported by Usman [18], though some significant differences ($P < 0.05$) were observed among the samples. The variation in the fat content is because of differences in raw material used in the formulation of the breakfast cereals The level of Jackfruit seed flour in the formulation might be responsible for the slight increase in the fat content of the resultant products because there was an increase in the fat content with addition of Jackfruit seed flour (JSF) in the maize flour even though the products were generally low in fat. Higher values of fate content (8.70 -14.32%) were recorded for breakfast cereal made from composite of AYB, maize, sorghum and soybean [20] and breakfast cereal made from Sorghum and pigeon pea composite flour [19]. The low fat contents of the formulated breakfast cereals may be suitable for weight watchers.

Table 3: Mean Values for the Proximate Composition (%) and Energy Values of Breakfast Cereal made from Blends of Maize and Jackfruit Seed flour

SAMPLE	MOISTURE	ASH	CRUDE FIBRE	PROTEIN	FAT	CARBOHYDRATE	ENERGY VALUE (kcal)
ABA	4.04±0.028[a]	3.62±0.021[b]	6.59±0.007[c]	11.91±0.007[d]	1.41±0.014[f]	72.79 ± 0.007[a]	396.67±0.064[b]
ABB	3.83±0.028[b]	3.19±0.007[c]	6.48±0.014[d]	11.65±0.014[e]	1.36±0.028[a]	73.49± 0.007[b]	398.90±0.098[c]
ABC	3.62±0.021[c]	2.87±0.014[d]	6.44±0.021[e]	11.26±0.014[f]	1.32±0.021[b]	73.97 ± 0.007[c]	400.98±0.162[d]
ABD	3.91±0.014[d]	2.05±0.014[e]	6.36±0.021[f]	11.06±0.028[a]	1.26±0.007[a]	73.37 ± 0.000[d]	410.92±0.078[e]
ABE	4.14±0.049[e]	3.86±0.014[f]	6.76±0.028[a]	12.15±0.021[b]	1.48±0.021[c]	71.63 ± 0.007[e]	387.92±0.311[f]
AAA	3.86±0.021[b]	1.89±0.007[a]	6.25±0.014[b]	4.19± 0.007[c]	1.10 ±0.014[d]	82.73 ± 0.021[f]	436.00±0.085[a]
LSD	**0.041**	**0.019**	**0.026**	**0.024**	**0.026**	**0.014**	**0.223**

Means with different superscripts along the columns differ significantly at P<0.05

Table 4: Mean Values for the Functional Properties of Breakfast Cereal from Blends of Maize and Jackfruit Seed flour

SAMPLE	BD (g/ml)	WAC (%)	OAC (%)	FC (%)	VIS (cps)	GC (%)
ABA	0.61±0.007[a]	2.01±0.007[b]	1.72±0.007[c]	32.01±0.014[e]	27.01±0.014[f]	78.01±0.014[a]
ABB	0.58±0.000[b]	2.03±0.014[c]	1.84±0.007[d]	32.40±0.000[f]	28.77±0.007[a]	80.42±0.007[b]
ABC	0.53±0.014[c]	2.10 ± 0.000[d]	1.91±0.014[e]	29.48±0.021[a]	30.03±0.014[b]	83.77±0.014[c]
ABD	0.54±0.000[d]	2.16±0.021[e]	1.92±0.021[e]	28.21±0.014[b]	31.91±0.014[c]	88.45±0.014[d]
ABE	0.66±0.021[e]	2.11±0.014[d]	1.52±0.014[a]	31.66 ±0.021[c]	25.12±0.021[d]	70.38±0.021[e]
AAA	0.51±0.007[f]	1.82±0.021[a]	1.47±0.007[b]	34.42±0.021[d]	33.11±0.007[e]	91.03±0.042[f]
LSD	**0.015**	**0.021**	**0.018**	**0.024**	**0.019**	**0.031**

Means with different superscripts along the columns differ significantly at P<0.05

KEY: BD = Bulk density; WAC = Water absorption capacity; OAC = Oil absorption capacity; FC = Foaming capacity; VIS = Viscosity; GC = Gelation capacity

AAA = 100% Maize flour
ABE = 50% Maize flour: 50% Jackfruit seed flour
ABA = 60% Maize flour: 40% Jackfruit seed flour
ABB = 70% Maize flour: 30% Jackfruit seed flour
ABC = 80% Maize flour: 20% Jackfruit seed flour
ABD = 90% Maize flour: 10% Jackfruit seed flour

The ash content analysis of the formulated breakfast cereal ranged from 1.89 to 3.86% and significant differences (P < 0.05) exists among the samples. The range of values obtained were lower than that recorded for a breakfast cereal made from composite of AYB, Maize and defatted coconut flour which had an ash content of 3.29 to 7.362% [18]. On the other hand, lower ash content values (1.36%) and (1.50 – 2.50%) were reported by Agunbiade and Ojezele [20] and Mbaeyi [19] respectively. The variation in the ash content is because of differences in raw material used in the formulation of the breakfast cereals. Sample AAA (control least value) recorded the least ash content of 1.89% while the highest ash content value of 3.86% was observed in sample ABE. The increase in ash content might be attributed to the substitution of maize flour with jackfruit seed flour as it could be observed that with any increase in jackfruit seed flour in the formulation there was increase in the ash content of the sample.

The crude fiber values of the formulated breakfast cereal samples ranged from 6.25 to 6.76%. There were significant differences (P < 0.05) amongst the crude fiber content of formulated breakfast cereals. However, lower ash content values of 3.1-3.8% and 1.54 – 4.0% have been reported by Agunbiade and Ojezele [20] and Mbaeyi [19] respectively for other breakfast cereal formulations. The variation in the crude fiber content is because of differences in raw material used in the formulation of the breakfast cereals. It was observed that the ash content of the formulated breakfast cereals increased with more addition of the jackfruit seed flour; as AAA (100% Maize flour) recorded the least ash content. Fiber is needed to assist in digestion and in keeping the gastrointestinal tract healthy and also help to keep the blood sugar stable. It also slows down the release of glucose during digestion [21]. The fecal bulking action of insoluble fiber makes it useful in the treatment of constipation and diverticular disease [22].

The mean values of carbohydrate content in the formulated breakfast cereals ranged from 71.63 to 82.73%. There were significant difference (P < 0.05) amongst the carbohydrate content of the formulated breakfast cereals. The carbohydrate content of the formulated breakfast cereal products were higher compared to the values recorded for breakfast cereal made from composite of AYB, Maize and defatted coconut flour (60.96 to 64 .53%) according to Usman [18] as well as the breakfast cereal made from sorghum and pigeon pea with a carbohydrate content of 64.4% [19]. The variation in the carbohydrate content is because of differences in raw material used in the formulation of the breakfast cereals. However, the carbohydrate content (82.73%) was recorded by sample AAA (100% Maize flour) while the least carbohydrate content (71.63%) was recorded by sample ABE (50% Maize flour: 50% Jackfruit seed flour). It was observed that an increase in the amount of JSF substituted for maize led to a corresponding decrease in the carbohydrate content of the formulated breakfast cereal samples.

The values obtained for the total energy contents of the formulated samples ranged from 387.92 to 436.00kcal and were found to be higher than the values recorded for breakfast cereal made from treated and untreated sorghum and pigeon pea with Energy value range of 316.46 - 420kcal [19]. Sample AAA had the highest energy value of 436.00kcal. The energy value decreased with increased substitution with JSF as evident in sample ABE (387.92kcal) which had the least Energy value probably because of its higher level of jackfruit seed flour substitution. Energy value represents the amount of energy in the food that can be supplied to the body for maintenance of basic body functions.

3.2 Functional Properties

The results of the evaluation of the functional properties of the formulated cereal is shown in Table 4. The bulk density of the formulated breakfast cereal ranged from 0.51g/ml to 0.66g/ml with the highest value found in sample ABE (50% Maize flour: 50% Jackfruit seed flour). There was an increase in the bulk density of the formulated breakfast cereal samples with increased addition of the Jackfruit seed flour (JSF). Higher values of bulk density (2.45 and 2.60%) were recorded by Agunbiade and Ojezele [20] for breakfast cereal made from maize, sorghum, African Yam Beam (AYB) and soybeans. The bulk density values obtained in this study are comparable to the values of 0.534-0.7267g/ml reported by Mbaeyi [19].

The water absorption capacity values of the formulated breakfast cereal samples ranged from 1.82 to 2.16%. There were significant differences (P < 0.05) between the samples except for sample ABC and sample ABE which showed no significant difference (P > 0.05) in WAC. The highest WAC value was found in sample ABD (2.16%) while the least was found in sample AAA (100% Maize Flour). The water absorption capacity was found to be increasing with increasing addition of the Jackfruit seed flour. The difference in water absorption is mainly caused by the greater number of hydroxyl group which exist in the fibrous structure allowing more water interaction through hydrogen bonding [23].

The oil absorption capacity values of the breakfast cereal ranged from 1.47 to 1.92% with the highest value recorded for sample ABD. The values obtained in this study was higher than the value of 0.87-1.32% reported by Usman [18] for a breakfast cereal made from composite of AYB, Maize and defatted coconut flour. Significant difference ($P < 0.05$) exists between the formulated breakfast cereal samples exception for sample ABD and sample ABC that showed no significant difference ($P>0.05$) in their OAC. However, the oil absorption capacity decreased with increased addition of the jackfruit seed flour in the flour blends.

The foam capacity values of the samples ranged from 13.07 to 37.41% with the highest foam capacity value observed in sample AAA (100% Maize Flour). There was a gradual decrease in foam capacity value with increased addition of jackfruit seed flour. The values obtained in this study were higher than the value of 1.98% recorded for flour obtained from boiled AYB [24].

The result for viscosity showed significant ($P < 0.05$) differences among the formulated breakfast cereal samples; with values ranging from 25.12 to 33.11cp. The least value was observed in sample ABE (50% Maize flour: 50% Jackfruit seed flour). Increased addition of the jackfruit seed flour caused a significant decrease in the viscosity. This could be as a result of the low carbohydrate content of the formulated breakfast cereal samples, as high starch presence tends to cause increased resistance to flow in food products and vice versa. The values recorded were higher than the values (19.73 – 31.08cp) recorded for a breakfast cereal made from AYB, Maize and defatted coconut flour [18]. The generally low viscosity values observed might be due to less disruption of intermolecular hydrogen bonds which brought about noticeable swelling of the granules and gelation [9].

The gelation capacity values of the formulated blends showed significant differences ($P < 0.05$) among the sample with values ranging from 70.38 to 91.03% and the highest gelation capacity value was found in sample AAA. A gel represents a transitional phase between solids and liquid states. In food system it could consists of protein, polysaccharides or a mixture of both, while the liquid is usually water. Ionic strength, pH and the presence of non-protein component can influence the gelation properties [25]. The result showed a gradual reduction in gelation capacity with increased substitution of the maize flour with jackfruit seed flour and this was evident in sample ABE which had the least gelation capacity value of 70.38%.

3.3 Mineral Content of the Breakfast Cereal

The mineral compositions of the formulated breakfast cereal samples are shown in Table 5. The calcium contents of the samples ranged from 156.23 to 184.14mg/100g with the highest observed in sample AAA (control) while the least value occurred in sample ABE. Higher calcium values (169mg/100g to 213mg/100g) were recorded for breakfast cereal made from blends of AYB, Maize and defatted coconut flour [18]. However, lower calcium values (156mg/kg) were also recorded for breakfast cereal made from maize, sorghum, soybean and African Yam Bean (AYB) composite flour [20] and breakfast cereals made from sorghum and pigeon pea with calcium value of 137.05-156.34mg/kg [19]. The calcium content values obtained in this study was lower than the US RDA for calcium (1000mg/100g). Thus, 100g of the formulated samples could provide about 15.6-18.4% of the US RDA. Calcium is one of the most important minerals that the body requires and its deficiency is more prevalent than any other mineral [11]. Since the formulated breakfast cereal samples contained a significant amount of the element, they could make an ideal meal for children and adult alike.

The magnesium contents of the cereal ranged from 179.28 to 207.81mg/100g. There are significant differences ($P < 0.05$) in the magnesium content among the formulated breakfast cereal samples. The highest value was recorded for sample AAA (control) and the least was recorded for sample ABE. These magnesium values were lower than those recorded by Usman [18] for a breakfast cereal made from AYB, Maize and defatted coconut flour with values ranging from 290.02mg/100g to 430.01mg/100g. The values obtained from this study was lower than the value recommended by US RDA for magnesium (280mg/100g and 350mg/100g) for women and men respectively.

Table 5: The Mineral Contents of Breakfast Cereal Samples Made from Blends of Maize and Jackfruit Seed Flours (mg/100g)

SAMPLE	CALCIUM	SODIUM	MAGNESIUM	PHOSPHORUS	POTASSIUM	IRON	ZINC
ABA	159.02±0.021^{a}	9.86±0.014^{b}	184.62±0.007^{c}	12.46±0.021^{d}	72.02±0.014^{e}	5.36±0.021^{f}	1.83± 0.007^{a}
ABB	162.16±0.028^{b}	10.02±0.007^{c}	187.34±0.014^{d}	11.88±0.021^{e}	71.96±0.021^{f}	5.16 ± 0.0^{a}	1.94±0.0^{ab}
ABC	178.52±0.014^{c}	10.22±0.021^{d}	190.64±0.021^{e}	11.24 ± 0.0^{f}	71.74±0.014^{a}	4.91±0.007^{b}	2.05±0.035^{bc}
ABD	180.61±0.007^{d}	10.48 ± 0.0^{e}	194.02±0.007^{f}	10.95±0.014^{a}	74.03±0.007^{b}	4.68±0.007^{c}	2.17±0.007^{c}
ABE	156.23±0.021^{e}	9.44±0.028^{f}	179.28±0.021^{a}	13.62±0.007^{b}	70.62±0.014^{c}	5.46±0.007^{d}	1.72±0.205^{ea}
AAA	184.14±0.028^{f}	10.66±0.014^{a}	207.81±0.007^{b}	10.33±0.021^{c}	78.53±0.014^{d}	4.01±0.014^{e}	2.29±0.205^{dc}
LSD	**0.03023**	**0.02377**	**0.020375**	**0.020308**	**0.02081**	**0.01629**	**0.120629**

Means with different superscripts along the columns differ significantly at $P<0.05$

Table 6: Anti-Nutritional Contents of Breakfast Cereal Made from Blends of Maize and Jackfruit Seed Flour (mg/100g)

SAMPLE	ALKALOID	SAPONIN	TANNIN	TRYPSIN INHIBITORS	PHYTATE
ABA	1.02 ± 0.014^{a}	0.11 ± 0.014^{c}	1.97 ± 0.007^{d}	8.45 ± 0.014^{e}	4.86 ± 0.021^{f}
ABB	0.99 ± 0.007^{b}	0.16± 0.007^{d}	1.91 ± 0.014^{e}	8.02 ± 0.014^{f}	4.71 ± 0.014^{a}
ABC	0.97 ± 0.007^{c}	0.2 ± 0.0^{e}	1.88 ± 0.007^{f}	7.86 ± 0.014^{a}	4.48 ± 0.0^{b}
ABD	0.88 ± 0.0^{d}	0.23 ± 0.014^{f}	1.82 ± 0.014^{a}	6.15 ± 0.021^{b}	4.28 ± 0.014^{c}
ABE	1.13 ± 0.014^{e}	0.08 ± 0.0^{a}	2.02 ± 0.0^{b}	9.01 ± 0.014^{c}	4.94 ± 0.007^{d}
AAA	0.82 ± 0.021^{f}	0.38 ± 0.014^{b}	1.03 ± 0.014^{c}	2.28 ± 0.014^{d}	0.36 ± 0.007^{e}
LSD	**0.017758**	**0.04682**	**0.01528**	**0.021978**	**0.017758**

Means with different superscripts along the columns differ significantly at $P<0.05$

KEY:

AAA = 100% Maize flour
ABE = 50% Maize flour: 50% Jackfruit seed flour
ABA = 60% Maize flour: 40% Jackfruit seed flour
ABB = 70% Maize flour: 30% Jackfruit seed flour
ABC = 80% Maize flour: 20% Jackfruit seed flour
ABD = 90% Maize flour: 10% Jackfruit seed flour

Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerves [26]. Magnesium works with calcium to assist in muscle contraction, blood clotting and the regulation of blood pressure and lung function [27]. The breakfast cereal could make an ideal meal for both men and women since it contained a significant amount of the element.

The potassium content of the breakfast cereal ranged from 70.62 to 78.53mg/100g. There were significant differences ($P < 0.05$) among the samples with the highest value observed in the sample AAA and the least observed in sample ABE. It was also observed that there was consequent decrease in the potassium content with an increase in the amount of jackfruit seed flour substituted for maize flour in the formulation. The range of potassium content were lower than the values of 88.00 to 191.00mg/100g recorded for a breakfast cereal made from AYB, Maize and defatted coconut flour [18] but higher than the US RDA for both men and women (3.5mg/100g). Lower values of 70.19mg/kg were also recorded for fortified breakfast cereal [20]. 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 [26].

The iron content of the formulated breakfast cereal ranged from 4.01 to 5.46mg/100g with the highest value recorded for the sample ABE and the least for sample AAA. 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 – 14.10mg/100g [18] and also lower than the value of 13.46±1.74mg/100g for a breakfast cereal made from maize, sorghum, soybean and AYB composite flour [20]. The formulated breakfast cereal samples were also lower than the US RDA (10-15mg/100g). Inadequate iron intake causes iron deficiency anemia (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 breathe [28].

The result of the sodium content shows significant ($P < 0.05$) differences in the samples with values ranging from 9.44 to 10.66mg/100g. Higher values (97.5-187.3mg/100g) were reported for fortified breakfast cereals [19]. These values obtained were far less than the US RDA (500mg/100g). The generally low amount of sodium in the product could be attributed to the low amount of salt added during the preparation of the breakfast cereal. Sodium is normally consumed as a form of salt and it is essential in the regulation of water content and in the maintenance of osmotic pressure of the body fluid. It also aids in the transportation of CO_2 in the blood. However, sodium is one of the mineral whose intake is considered a factor in the etiology of hypertension, hence its low intake is encouraged [29]. The formulated breakfast cereal products recorded low sodium content, it implies that the product may be ideal for adults.

The zinc content of the formulated breakfast cereal samples ranged from 1.72 to 2.29mg/100g with the highest value recorded in sample AAA (control) and the least value recorded in sample ABE (50% substitution). The result also showed a reduction in the zinc content with subsequent increase in the amount of Jackfruit seed flour added to the formulation. Higher values were observed for a breakfast cereal sample made from AYB, soybean and defatted coconut flour (1.97 -3.35mg/100g). The values obtained were lower than the US RDA (15mg/100g for men and 12mg/100g for women). Lower values of 1.54 to1.64mg/kg were recorded for fortified breakfast cereal reported Agunbiade and Ojezele [20]. 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 [28].

The phosphorus content of the formulated breakfast cereal samples ranged from 10.38 to 13.62mg/100g. There were significant ($P < 0.05$) differences among the sample with regards to phosphorus contents. The highest value was observed in sample ABE (13.62mg/100g) while the least value was observed in sample AAA (control). The results obtained were less than the values (188-289mg/100g) recorded for a breakfast cereal made from blends of Acha and fermented Soybean paste (okara) [30]. The results revealed that the phosphorus content of the formulated samples increased with increasing addition of the jackfruit 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.

3.4 Anti-Nutritional Content

The anti-nutritional contents of the formulated samples are shown in Table 6. The alkaloid contents in the formulated breakfast cereal samples were relatively low with values ranging from 0.82 to 1.13mg/100g. The values obtained showed significant (P < 0.05) differences between the samples with the highest value observed in sample ABE (1.13mg/100g) and the least value in sample AAA (control) (0.82mg/100g). The result revealed that the alkaloid contents increased slightly with increasing addition of Jackfruit seed flour in the formulations. Alkaloids are one of the largest group of chemical compounds synthesized by plant and generally found as salt of acids such as oxalic. Malic, tartaric or citric acid [31]. Alkaloids are considered anti-nutrients because of their action on the nervous system, disruption or inappropriately augmenting electrochemical transmission. For instance, consumption of high tropane alkaloids will cause rapid heartbeat, paralysis and in fatal case, lead to death. Uptake of high dose of tryptamine alkaloids will lead to staggering gate and death. Other toxic action includes disruption of the cell membrane in the gastrointestinal tract. Also cholinesterase is greatly inhibited by glycoalkaloid [32].

The result obtained for the saponin content of the formulated breakfast cereal samples were found to be remarkably low with values ranging from 0.08 to 0.38mg/100g. There was significant (P < 0.05) differences between the samples. The highest value was recorded for sample AAA (control) while the least was recorded in sample ABE. The result revealed that the saponin contents of the breakfast cereal decreased with increased addition of the Jackfruit seed flour in the formulation as evident in the sample ABE having the least saponin values but with the highest jackfruit seed flour. Saponins are secondary compounds that are generally known as non-volatile, surface active compound which are widely distributed in nature [31]. Saponin in high concentrations imparts a bitter taste and astringency in dietary plants. Saponins were found to reduce the bioavailability of nutrients decrease enzyme activity and also affect protein digestibility by inhibiting various digestive enzymes such as trypsin and chymotrypsin [33].

The tannin content of the formulated samples was significantly (P < 0.05) different between the sample with values ranging from 1.03 to 2.02mg/100g. The lowest value was recorded in sample AAA (control). There was some gradual increase in the tannin content of the breakfast cereal with increasing addition of the Jackfruit seed flour in the formulation. Lower values (0.00064 to 0.0016mg/100g) were reported for a breakfast cereal made from African Yam Bean (AYB), Maize and Defatted coconut flour [18] and (0.035 to 0.130mg/100g) for a breakfast cereal made from pigeon pea and sorghum [19]. Tannins are heat stable and they can decrease protein digestibility in animals and humans either by making proteins partially unavailable or inhibiting digestive enzymes and increasing fecal nitrogen [31]. Tannins are known to inhibit the activities of trypsin, chymotrypsin, amylase and lipase, decrease the protein quality of food and interfere with dietary iron absorption [34]. If the tannin concentration in a diet becomes too high, microbial enzyme activities including cellulose and intestinal digestion may be depressed [35]. Tannin also form insoluble complexes with proteins and the tannin-protein complexes may be responsible for the anti-nutritional effect of tannin containing food [36].

The trypsin inhibitor content of the formulated samples was significantly different at (P < 0.05) with values ranging from 2.28 to 9.01mg/100g. The highest value was observed in sample ABE while the lowest value was observed in sample AAA (control). The result revealed an increase in the trypsin inhibitor content with increasing addition of the jackfruit seed flour in the formulation. This shows that the jackfruit seed had more of the trypsin inhibitor probably because of it relatively high protein content. Trypsin inhibitor is a protease inhibitor occurring in raw leguminous seeds. Protease inhibitors are the most commonly encountered class of anti-nutritional factors of plant origin. Protease inhibitors have the ability to inhibit the activity of proteolytic enzymes within the gastrointestinal tract of animals, but they can be easily denatured by heat due to its protein nature although some residual activity may still remain in the commercially produced products [31]. Trypsin inhibitors can inhibit the activity of the enzymes trypsin and chymotrypsin in the gut, thus preventing protein digestion. Trypsin inhibitors inhibits protease enzymes in the digestive tract by forming indigestible complexes with dietary protein [37].

The result obtained for the phytate contents of the formulated product ranged from 0.36 to 4.94mg/100g. Some gradual increase of the phytate was observed with increase in the level of the jackfruit seed flour added. The highest value was observed in sample ABE while the least was observed in sample AAA (control). The result obtained in this study was higher than that (0.38 to 1.25mg/100g) recorded for a breakfast cereal made from AYB, Maize and defatted coconut flour [18]. The increase in phytate might be attributed to the presence of high dietary fiber in JSF [8]. Many fibers contain phytic acid which binds minerals in the digestive tract and eventually expels the minerals from the body. Some of these minerals are essential for good health, including zinc, iron and calcium. Although health experts recommend increasing intake of dietary fiber, eating too much fiber containing phytic acid can cause mineral deficiencies [38]. The Phytate works in a broad pH region as a highly negatively charged ion and therefore its presence in the diet has a negative impact on the bioavailability of divalent and trivalent mineral ions such as Zn^{2+}, $Fe^{2+/3+}$, Ca^{2+}, Mg^{2+}, Mn^{2+} and Cu^{2+}. Whether or not high levels of consumption of phytate containing food will result in mineral deficiency will depend on what else is being consumed [31].

3.5 Sensory Evaluation

The mean sensory scores of the formulated breakfast cereal samples are shown in Table 7 below. The sensory parameters evaluated includes appearance, consistency, flavour, taste, aftertaste, mouthfeel and general acceptability of the formulated breakfast cereal products. The results showed that there was significant difference (P >0.05) in appearance and consistency of the formulated breakfast cereals but sample ABE (50% Maize Flour: 50% Jackfruit Seed Flour) with the highest appearance score of 7.20 was moderately liked by the panelists while sample ABC (80% Maize Flour: 20% Jackfruit Seed Flour) with the highest consistency score of 6.40 was liked slightly by the panelists. On the other hand, there was no significant difference (P>0.05) in the flavour, taste, aftertaste, mouthfeel and general acceptability of the formulated breakfast cereal products except for sample ABE (50% Maize Flour: 50% Jackfruit Seed Flour). Sample AAA (100% Maize Flour) recorded the highest sensory scores while Sample ABE recorded the least sensory scores for all the aforementioned sensory parameters. It could be that the panelists disliked the sample ABE because of the 50% Jackfruit seed flour substitution. Amongst flavour, taste, aftertaste, mouthfeel and general acceptability of the formulated breakfast cereals products measured, the panelist preference which was represented as sensory scores increased with a corresponding decrease in Jackfruit seed flour addition. It is therefore evident that the concentration of jackfruit seed flour incorporation influenced the panelist's preference of the formulated products.

Table 7: Mean Sensory Scores of Breakfast Cereal made from Blends of Maize and Jackfruit Seed flours

SAMPLE	APPEARANCE	CONSISTENCY	FLAVOUR	TASTE	AFTERTASTE	MOUTHFEEL	GENERAL ACCEPTABILITY
AAA	6.80±1.264	6.07 ± 1.033	6.80^{a}±1.424	7.20^{a}±1.207	5.83^{a}±1.047	5.20^{a} ± 1.474	6.53^{a} ± 1.246
ABA	6.47±1.302	5.87± 1.356	5.33^{a}±1.496	5.47^{a}±1.362	4.87^{a}±1.552	3.73^{a} ±1.676	5.27^{a}± 1.056
ABB	6.60±1.594	5.40 ±1.404	5.87^{a}±2.416	6.00^{a}±1.928	5.10^{a} ±1.805	4.27^{a}±1.579	5.60^{a} ± 1.727
ABC	6.27±1.792	6.40 ± 2.229	6.13^{a} ±1.356	6.20^{a}±1.506	5.27^{a}±2.024	4.67^{a}±1.579	5.60^{a}± 1.486
ABD	6.40 ±1.352	5.87 ± 1.552	6.20^{a} ±1.740	7.00^{a}±1.780	5.47^{a}±1.335	5.07^{a}±1.981	6.13^{a}± 1.549
ABE	7.20 ± 1.781	5.87 ± 1.846	4.40^{b}±1.595	3.67^{b}±2.160	2.47^{b}±1.598	2.30^{b} ± 1.759	2.60^{b} ± 2.414
LSD	**NS**	**NS**	**1.96**	**1.94**	**1.83**	**1.93**	**1.88**

Means with different superscripts along the columns differ significantly at $P<0.05$

KEY:

AAA = 100% Maize flour

ABE = 50% Maize flour: 50% Jackfruit seed flour

ABA = 60% Maize flour: 40% Jackfruit seed flour

ABB = 70% Maize flour: 30% Jackfruit seed flour

ABC = 80% Maize flour: 20% Jackfruit seed flour

ABD = 90% Maize flour: 10% Jackfruit seed flour

4. CONCLUSION

The incorporation of various proportions of jackfruit seed flour into maize flour in breakfast cereal formulation significantly influenced the proximate composition, functional properties and mineral content of the formulated breakfast cereal products. The most preferred substitution level of Jackfruit seed flour to maize flour in the production of breakfast cereal is 70% Maize Flour: 30% Jackfruit Seed Flour, in terms of sensory attributes and from nutritional point of view. The study showed increased addition of Jackfruit Seed Flour increased the protein, ash, crude fiber and fat content of the breakfast cereals with a decrease in carbohydrate content. The toasting process played a significant role in reducing the relatively high level of anti-nutrients associated with Jackfruit seed and moisture content (3-4%) of the formulated breakfast cereal product which is important for reduced weight and extension of the shelf life of the product. Utilization of Jackfruit in product development is a means of reducing wastage due to postharvest losses of the fruit and also serve as a cheap source of nutrients.

COMPETING INTEREST

Authors have declared that no competing interest exists.

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