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Chemical, Microbial, and Sensory Properties of Breakfast Cereals Made from Yellow Maize and Soybean Flour Blends with Firmly Ripe Banana Flavoring

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Abstract

This study formulated breakfast cereals by combining yellow maize, soybean, and ripe banana flours to enhance nutritional and sensory properties Composite flour was formulated by mixing yellow maize flour and soybean flour in a 70:30 ratio. Five samples of breakfast cereals were then produced by blending the composite flour with banana flour at varying ratios: 95:5 (Sample A), 90:10 (Sample B), 85:15 (Sample C), 80:20 (Sample D), and 75:25 (Sample E). A control sample was also produced, consisting of 100% of the yellow maize and soybean composite flour in the 70:30 ratio without banana flour. The samples were evaluated to determine proximate composition, mineral and vitamin content, microbial and sensory qualities. Results of moisture content of breakfast cereals ranged from 3.41 to 3.61%. Protein and lipid decrease significantly ($P<0.05$) from 12.65 to 9.31% and 9.94 to 3.61% with increasing ripe banana flour substitution respectively. Fibre and carbohydrate content of breakfast cereal increased significantly ($P<0.05$) with increase in banana flour from 2.90 to 4.53% and 53.92 to 75.77% respectively. Energy value of the cereal decreased (382.76- 372.85 kcal/100g) with increasing addition of ripe banana flour in the composite blends. For mineral content, there was a significant difference ($P<0.05$) among the samples. Sample E (75:25) had the highest value in potassium (233 mg/100g). The highest content of magnesium was observed in sample D, E and F (43mg/100g). Vitamin A content of breakfast cereal decreases significantly ($P<0.05$) from 7.8 to 2.1 mg/100g with increase in ripe banana flour. Vitamin C content increases significantly ($P<0.05$) from 1.84 to 5.17 mg/100g with increase in ripe banana flour. Microbial analysis revealed the following ranges: Bacteria count, $1.26x10^5$ – $5.00x10^4$ Cfu/g, fungi count, $0.0x10^4$ – $1.0x10^4$ Cfu/g. In sensory evaluation, breakfast cereals served dry and with milk, indicated that sample F and sample A had the highest level of acceptability (7.00), (6.91) respectively among other samples. These results suggest that incorporating ripe banana flour into yellow maize and soybean-based cereals can modify their nutritional and sensory attributes, offering a potentially healthier and palatable breakfast option.

Keywords: *Breakfast Cereals, yellow maize, soybean, firmly ripe banana, composite flour*

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1. Introduction

Breakfast cereals now constitute an important component of the human diet, especially for children, as they are a great way to improve consumer health (Félix-Medina *et al.* 2020). Breakfast cereals can be manufactured by the extrusion process and are typically made from starchy ingredients such as wheat, corn, barley, rice, and oats (Ferreira *et al*., 2012). Consumer acceptability of breakfast cereals is primarily influenced by appearance, nutritional profile, texture, and convenience (Ferreira *et al*., 2021). Breakfast cereals are a good source of vitamins and minerals; however, they are also important source of polyphenol and antioxidants (Ryan *et al.*, 2011). Breakfast cereals are defined as processed grains for human consumption. (Caldwell *et al.*, 2016). Nutritional experts over the years have stated that breakfast is the most crucial meal of the day and studies have shown that people who skip breakfast are likely to have problems with concentration, metabolism, and weight (Mayo Clinic, 2009).

Breakfast meals always include a carbohydrate source which could be supplemented with a leguminous source such as African yam bean, Bambara groundnut and in this case, soybean. The reason cereals are usually supplemented with legumes is because it is deficient in lysine (Onweluzo and Nnamuchi, 2009). When cereals are combined with legumes

rich in lysine, it supplements for the lysine in cereal (Mbaeyi-Nwaoha and Uchendu, 2016).

Yellow maize is a pro vitamin A fortified maize that has the potential of addressing vitamin A deficiency which is a major public health concern in Nigeria and Africa at large (Pillay *et al.*, 2011). Among different cereals, maize (Zea mays L.), often referred to as the "poor man's nutri-cereal," offers numerous opportunities due to its diverse applications in food, feed, and industry. As a food source, it supplies around 30% of the calories for roughly 4.5 billion people in 94 developing countries. Globally, 63% of maize is utilized for livestock feed, in addition to its significant role as a source of oil, starch, and biofuel (Shiferaw et al., 2011). Soybean, a legume with protein levels comparable to animal protein, contains approximately 40-45% protein by total solids (Goyal et al., 2012). Economically, soybean is the most crucial bean globally, supplying vegetable protein to millions and serving as a key ingredient in numerous chemical products (Edima-Nyah et al., 2019). It is a rich source of vitamins and minerals (Iwe, 2003).

Bananas are edible fruits produced from several kinds of large herbaceous flowering plants in the genus Musa (Morton, 2013). They vary in color, size and firmness but typically elongated and curved, the fruit has soft, starchy flesh and is covered by a rind that can be green, yellow, red, purple, or brown when ripe depending on the cultivar (Armstrong, 2013). Raw bananas (excluding the peel) are composed of 75% water, 23% carbohydrates, 1% protein, and contain minimal fat (Duval, 2017). They are also a valuable source of vitamin B6, moderate amounts of vitamin C, Manganese, Potassium, dietary fibre etc. (Arnarson, 2014). The main aim of this research is to produce breakfast cereals from different flour blends consisting of yellow maize *(Zea may)*, soya beans *(Glycine max)* flavoured with ripe banana.

This research therefore has the potential to address the problem of vitamin A malnutrition and decreased in the production of vitamin A rich food as well as provision of essential amino acid needed by the body for growth and maintenance. Therefore, processing yellow maize into an acceptable and ready-to-eat product containing adequate amount of the vitamin A precursor (β- carotene) together with a leguminous source (soybeans) will be of great interest and benefit to the consumers.

2. Materials and Methods

2.1 Materials Procurement

Yellow maize grains (*Zea mays*), soya beans (*Glycine max*), mature, ready-to-ripe banana (*Musa sapientum*), sugar and salt were the materials used, and they were purchased from Itam main market, Itu, in Akwa Ibom State, Nigeria. Other materials and equipment used were gotten from the Food Science and Technology Laboratory, University of Uyo, Akwa Ibom State.

2.1.1 Sample Preparation

Yellow maize grains were thoroughly sorted and cleaned to eliminate any extraneous materials such as dust, stones, dirt, chaff, defective grains, and other undesired substances before proceeding with further processing. The soybean was sorted, washed, cleaned, steeped, dehulled before milling. Milling was properly done to get a fine flour. Matured and ready to ripe banana bunch was place in the laboratory bench to monitor the onset of ripening. Colour change of the peel from green to light yellow was used as an indicator. When the colour change was observed, the banana fingers were washed, cleaned, and peeled properly before proceeding with processing.

2.1.2 Production of Yellow Maize Flour

The method used was the method stated by Ihekoronye and Ngoddy (1985). About 2 kg of cleaned and sorted yellow maize grains were washed with potable water to remove any dirt. The washed grains were dried in an oven at 60°C for 24 hours. It was milled into flour using attrition milling machine and packages for further analysis.

2.1.3 Production of Soybean Flour

The soybean flour was made following the procedure outlined by Bolarinwa et al. (2016). Raw soybean was sorted to remove defected grains, washed, steep in water in the ratio 1:3 for 10 hours and dehulled (by rubbing with palms), and the hulls were removed by rinsing with clean water before drying. The drying was done using an oven at 80°C for 18 hours. The soybean was then milled to get flour. The soybean flour was sifted through a 425-micrometer mesh screen, then sealed in an airtight plastic container, labeled, and stored at room temperature (27±2°C) for future use.

2.1.4 Production of Banana Flour

The banana flour was produced following the method described by Ovando-Matinez *et al.* (2009). Firmly ripened banana was washed, peeled, and chopped into uniform sizes before drying. Drying was done using an oven at 60°C for 18 hours. It was then ground and sieve into fine flour. The grounded flour was packaged and stored at room temperature for further use.

2.1.5 Formulation of Flour Blends

Composite flour was formulated by mixing yellow maize flour and soybean flour at the ratio of 70:30. Five samples of breakfast cereals were produced by mixing the composite flour (made of Yellow Maize and Soybean flour) with banana flour at the ratio of 95:5=A, 90:10=B, 85:15=C, 80:20=D, 75:25=E. A control sample of 100% yellow maize flour and soybean flour at the ratio of 70:30 was produced. Table 1 shows the composite flour formulation of breakfast cereals made from blends of yellow maize (YM) and Soybean (SB): Banana (BN) flour. Table 2 shows ingredients for breakfast cereals made from blends of YM-SB+BN flour per 400g.

Table 1. Composite flour formulation for breakfast cereals using blends of yellow maize (YM), soybean (SB), and banana (BN) flour

Sample	Sample code	Code ratio
A	YM-SB:BN	95:5
B	YM-SB:BN	90:10
C	YM-SB:BN	85:15
D	YM-SB:BN	80:20
E	YM-SB:BN	75:25
F (Control)	YM-SB:BN	100:0

Table 2. Recipe standard for breakfast cereals using blends of YM-SB+BN flour per 400g.

Ingredients	A	B	C	D	E	F
YM-SB+BN(g)	400	400	400	400	400	400
Sugar (g)	56	56	56	56	56	56
Salt (g)	4	4	4	4	4	4
Water (ml)	200	200	200	200	200	200

Source: Modified from Edima-Nyah *et al.* (2019)

2.1.6 Breakfast Cereal Production

The method described by Okafor and Usman (2014) was used for the production of breakfast cereals. The breakfast cereal was made by mixing the composite flour of yellow maize and soybean with the banana flour. Sugar, salt and water was added and mixed manually. The mixing was done thoroughly. The dough obtained was kneaded on a flat surface and passed through Euroson Globe150 cold extruder (model: MC-8830). The extruded dough was put in an oven (NAAFCO BS Oven, model: OVH-102) and dried at 80^{o}c for 2 hours until a dry extruded breakfast cereal was achieved. The products were allowed to cool and packaged in air-tight containers, labelled and used for various analysis. Figure 1 shows the photographs of produced breakfast cereal.

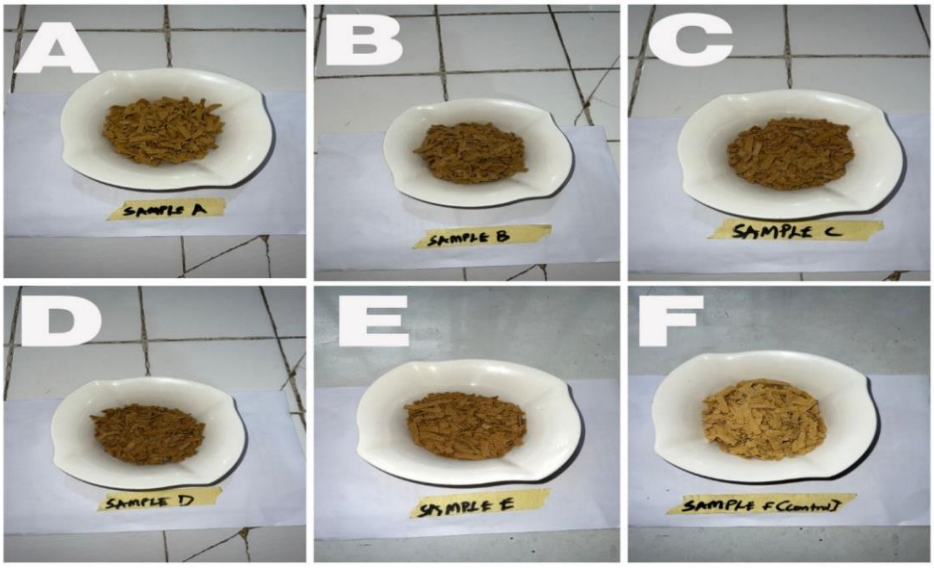

Figure 1. Produced breakfast cereal. ***A****= 95:5 (YM-SB:BN);* ***B*** *= 95:5 (YM-SB:BN);* ***C****= 85:15 (YM-SB:BN);* ***D****=80:20 (YM-SB:BN);* **E**=75: 20 (YM-SB:BN); **F**(control) = 100:0 (YM-SB:BN). YM- Yellow maize; SB- Soybean; BN- Banana

2.2 Method of Analysis

2.2.1 Proximate composition analysis

The standard method of AOAC (2010) was followed to determine moisture content, crude fat, crude protein, Ash, crude fiber and carbohydrate. The Atwater system described by Merrill *et al.* (1973) was used to determine the total energy value employing the 4-9-4 method

2.2.2 Determination of mineral content

The mineral content was determined following the method described by Fraga *et al.* (2004).

2.2.3 Determination of vitamin

Vitamin A was determined using the method described by Jakutowick *et al.*, (1997) using the spectrometric method, and Vitamin C (Ascorbic acid) was determined according to the 2, 6 – dichlorophenol titermetric method of AOAC (2010).

2.2.4 Microbiological Determination

2.2.4.1 Determination of total bacterial and fungal load count

Bacterial and fungi count was done following the method described in Benson (2005)**.**

2.2.5 Sensory evaluation of breakfast cereal

Sensory characteristics of breakfast cereals were evaluated for different sensory attributes by twenty (20) semi trained panelists drawn from the Department of Food Science and Technology, University of Uyo. All the panelists were briefed before the commencement of the evaluation process. The samples were served raw/dry and with cold milk. Sensory attributes evaluated were colour, taste, flavour, mouthfeel and overall acceptability. The nine (9) point hedonic scale as stated by Ihekoronye and Ngoddy (1985) was used to carry out the sensory evaluation. All panelists were conversant with the attributes of breakfast cereals. Room temperature water was provided for rinsing the mouth between assessment. Data obtained were statistically analyzed to determine the level of significance.

2.2.6 Statistical Analysis

All the data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were then separated with the use of Duncan New Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) 23.0 software.

3. Results and Discussion

3.1 Proximate Composition of Breakfast Cereals

The proximate composition and energy value of the breakfast cereal are presented in Table 3. The table shows that the moisture content of the samples was statistically different from each other ($P<0.05$). There was an increase in moisture content across the sample. This could be as a result of the increased in

the percentage composition of banana. However, low moisture content was generally observed. Edima-Nyah *et al.,* 2019 also observe a similar low moisture content from breakfast produced from blends of yellow maize, soybean and unripe banana.

There was a decrease in the protein content from sample A (95:5) to sample E (75:25), and an increase in sample F (70% yellow maize and 30% soybean). The protein content obtained ranged from 9.31±0.01 to 12.65±0.05 %. The range of crude protein values obtained in this study was close to the value (9.25- 14.75 %) by Edima-Nyah *et al.,* (2019) for yellow maize, soybean and unripe banana-based breakfast cereal. The high amount of protein in the samples especially in sample containing higher level of soybean shows the effect of supplementing legumes (such as soybean) in breakfast cereals (Usman, 2012). This therefore means that products made from the soybean fortified flour could be used to alleviate the problem of protein – energy malnutrition that is still prevalent in countries like Nigeria (Inyang *et al.,* 2019).

Fat content decreased with decreased in the amount of yellow maize-soybean composition in the breakfast cereals formulation. Sample F the control sample, with 70% composition of yellow maize and 30% of soybean had the highest value of fat content (4.94±0.03). The increase in the fat content could be as result of the percentage of fat present in the germ of cereal like that of the yellow maize (Manley, 2000) and the oil content of soybean. Edima *et al.,* 2019 reported a similar range of about 2.15±0.02 to 4.82±0.14. However, Mbaeyi-Nwaoha and Uchendu, (2016) reported a range from 1.57 to 16.29 % fat. Low fat content of these products could be beneficial to individual interested in watching their weight (Agunbiade and Ojezele, 2010).

The ash content decrease as they are decrease in yellow maize and soybean. Sample F (70% yellow maize and 30% soybean) has the highest percentage of ash content (4.22±0.02) compared to others. Lower values, 1.36-0.05% (Agunbiade and Ojezele, 2010) and 1.50-2.50% (Mbaeyi, 2005) were recorded by other researchers. The high ash values of ash recorded in this study may be as a result of the presence of whole yellow maize grains and banana used as part of the material in this study.

Fibre content decreased with decreasing addition of maize-soybean and increase with the addition of the banana flour in the blend. Sample E (75:25) has the highest level of crude fiber (4.53±0.02) and sample F (2.90±0.02) with no percentage composition of banana flour has the least amount of crude fiber.

Carbohydrate content of breakfast cereals ranged from 53.92±0.31 to 75.77±0.06 %. Carbohydrate content increased significantly with increasing addition of the banana flour in the blend formulations. There was no significant ($P<0.05$) different from each sample. However, sample F containing no blends of banana flour showed a significantly ($P<0.05$) lower carbohydrate content (53.92±0.31) than other blends. Bananas are a good source of carbohydrate, mainly starch. The carbohydrate values in this work are higher than those recorded by Usman, (2012) with values ranging from (60.96±1.42 – 64.53±0.05 %).

The caloric (energy) value of the breakfast cereals ranged from 372.85 (Kcal/100g) in the sample E (75% Yellow maize-soybean and 25% banana) to 382.76 (Kcal/100g) in the control sample. These values represent the percentage amount of energy in food that can be supplied to the body for maintenance of basic body functions such as breathing, circulation of blood, physical activities and thermic effect of food. (Edima-Nyah *et al.,* 2019). Energy value decreased with increasing addition of the banana flour in the formulation, and a corresponding decrease in fat content.

Table 3. Proximate composition of breakfast cereals produced from yellow maize-soybean blends flavoured with firmly ripe banana flour

Sample	Moisture %	Protein %	Lipid %	Ash %	Fibre %	Carbohydr-ate %	Energy Kcal/100g
A (95:5)	3.58^{a}±0.01	12.25^{b}±0.5	4.84^{b}±0.04	3.81^{b}±0.02	3.14^{e}±0.02	72.36^{a}±0.01	382.04^{a}±0.16
B (90:10)	3.45^{b}±0.02	11.72^{c}±0.02	4.50^{c}±0.00	3.71^{c}±0.02	3.50^{d}±0.02	73.10^{a}±0.07	379.81^{b}±0.23
C (85:15)	3.45^{b}±0.01	10.92^{d}±0.2	4.16^{d}±0.05	3.60^{d}±0.00	3.82^{c}±0.02	74.03^{a}±0.04	377.24^{c}±0.29
D (80:20)	3.41^{bc}±0.01	9.83^{e}±0.03	3.75^{e}±0.01	3.43^{e}±0.02	4.22^{b}±0.02	75.33^{e}±0.06	374.47^{d}±0.29
E (75:25)	3.61^{a}±0.03	9.31^{f}±0.01	3.61^{f}±0.01	3.16^{f}±0.02	4.53^{a}±0.02	75.77^{a}±0.06	372.85^{e}±0.07
F(control)	3.36^{f}±0.05	12.65^{a}±0.05	4.94^{a}±0.03	4.22^{a}±0.02	2.90^{f}±0.02	53.92^{b}±0.31	382.76^{a}±0.26

Values are means ± standard deviation of triplicate determinations. Means in the same row with different superscript are significantly ($P<0.05$) different.

3.2 Mineral Composition of Breakfast Cereals

Results of the mineral composition of the breakfast cereal formulated from yellow maize-soybean blends flavoured with firmly ripe banana flour is shown in the Table 4. Potassium content of the samples showed significant difference ($p<0.05$) between the samples. The test result ranged from 182 mg/100g to 223mg/100g. Sample E had the highest mean value while sample F had the lowest value. Bananas are good sources of potassium (Abdel-Wahab *et al.,* 1999) which explains why the sample with the highest percentage of banana flour blends has the highest potassium content and vice versa. The Magnesium contents test result showed that there were slight significant differences ($p<0.05$) between the samples. The test result ranged from 23 to 43mg/100g. Samples D, E and F had higher values while samples C and B had the values at alpha level of significance $p>0.05$.

3.3 Vitamin Content of Breakfast Cereals

The vitamin A content ranges from 2.1 mg/100g to 7.8 mg/100g. The values were increasing with increase in the percentage composition of yellow maize. This could be as a result of the presence of beta carotene in the yellow maize. The highest value was seen in sample F containing 70% of yellow maize and 30% of soybean. However, Edima-Nyah *et al.,*2019

recorded a much higher values ranging from 11.30 to 21.15 mg/100g in breakfast cereals from blends of local rice, African yam beans and coconut flour. Vitamin A is an essential vitamin and its deficiency in the body cause night blindness (Ojimelukwe *et al*., 2005). The US Recommended daily allowance (USRDA) for vitamin A is 5000 I.U.

Table 4. Mineral composition of breakfast cereal produced from blends of yellow maize and soybean flavoured with blend of firmly ripe banana flour

Sample	Potassium (K) (mg/100g)	Magnesium (Mg) (mg/100g)
A	183^{c}±0.005	40^{a}±0.006
B	185^{c}±0.005	23^{b}±0.004
C	193^{b}±0.005	23^{b}±0.007
D	196^{b}±0.005	43^{a}±0.006
E	233^{a}±0.005	43^{a}±0.005
F	182^{c}±0.005	43^{a}±0.005

Values are means ± standard deviation of triplicate determinations. Means in the same row with different superscript are significantly (P<0.05) different

Vitamin C ranged from 1.84 mg/100g to 5.17 mg/100g. The result showed that sample F (70:30 % of yellow maize and soybean) showed a significantly low value and sample E (75: 25) showed the highest value for vitamin C. This is as a result of increased percentage composition of the firmly ripe banana flour in sample E since firmly ripe banana tend to have moderate amount of vitamin C (Aurore *et al.,* 2009). Lower values (1.70-2.65mg/100g) were recorded by Okafor and Usman (2014) in maize, African yam bean and coconut-based breakfast cereal. Vitamin C is required in the body for the maintenance of health, gum, healing of wounds, and it act as a powerful antioxidant. Its deficiency will cause sore gum and scurvy (Ojimelukwe *et al*., 2005).

Table 5. Vitamins composition of breakfast cereals produced from blends of yellow maize and soybean flavoured with blend of firmly ripe banana flour**.**

Sample	Vitamin (mg/100g) A	C
A	6.1^{b}±0.01	3.19^{e}±0.01
B	5.5^{c}±0.02	3.50^{d}±0.00
C	4.5^{d}±0.02	4.71^{c}±0.01
D	3.5^{e}±0.01	5.12^{b}±0.02
E	2.1^{f}±0.01	5.17^{a}±0.04
F	7.8^{a}±0.02	1.84^{f}±0.03

Values are means + standard deviation of triplicate determinations. Means in the same row with different superscript are significantly (P<0.05) different

3.4 Microbial Quality of Breakfast Cereals

3.4.1 Bacterial load and fungal load

Total bacterial count of the breakfast cereals ranged from 1.26 $\times 10^{5}$ to 5.00×10^{4} Cfu/g. The least significant difference (P<0.05) was observed in sample E with the mean value of 1.26 Cfu/g. Anon, (2001) stated 10^{4} Cfu/g as satisfactory acceptable and unsatisfactory quality being (10^{5} Cfu/g).

Table 4.5 shows the result of the fungal load of the breakfast cereal. Sample A was the only blend that shows the growth of fungi (1.00×10^{4}Cfu/g). There was no growth in blends from sample B to F.

The microbial count obtained in this study was within the recommended safe limit of 10^{2} to 10^{5} Cfu/g in the microbial guidelines for ready to eat foods adopted by the international commission of microbial specification of food.

Table 6. Bacteria and Fungi loads of breakfast cereal produced from blends of yellow maize and soybean flavoured with blend of firmly ripe banana flour

Sample	Bacterial Load (Cfu/g)	Fungal Load (Cfu/g)
A	$4.00^{c}\pm1.00\times10^{4}$	1.00×10^{4}
B	$1.66^{d}\pm0.57\times10^{4}$	Nill
C	$5.00^{a}\pm2.00\times10^{4}$	Nill
D	$1.50^{e}\pm8.02\times10^{5}$	Nill
E	$1.26^{f}\pm5.3\times10^{5}$	Nll
F	$4.66^{b}\pm0.57\times10^{4}$	Nill

Values are means ± standard deviation of triplicate determinations. Means in the same row with different superscript are significantly (P<0.05) different

3.5 Sensory Quality of Breakfast Cereals

3.5.1 Sensory quality of breakfast cereal served dry and with cold milk

Mean sensory scores of sensory attributes of breakfast cereals served dry as snack and with cold milk is shown in Table 7 and 8 respectively. The samples were evaluated based on appearance, taste, mouth feel, aroma and general acceptability. However, for the dry cereal, sample F (control) was the most preferred by the judges, then followed by sample B, E, A, C and finally D in a decreasing order. The cereal served with cold milk shows mean sensory score for appearance ranging from 6.45 to 7.45. There was no significance (P>0.05) difference among samples A, C, D and F, and sample B and E respectively. Mean sensory score for taste was statistically (P<0.05) the same, within the range 6.09-6.91. Mouth feel had a mean sensory score ranging from 5.18 to 6.64 and sample A and C were significantly (P<0.05) different from others.

Table 7. Mean Sensory Score of Breakfast Cereal Served Dry

Sample	Appearance	Taste	Mouth feel	Aroma	General Acceptability
A	$7.82^{a}\pm1.16$	$7.18^{a}\pm1.23$	$6.91^{a}\pm1.44$	$6.82^{a}\pm0.98$	$6.36^{b}\pm1.21$
B	$7.00^{a}\pm1.18$	$6.64^{b}\pm1.02$	$6.27^{a}\pm1.43$	$6.36^{a}\pm1.12$	$6.64^{b}\pm1.23$
C	$6.09^{b}\pm1.51$	$5.45^{c}\pm1.23$	$5.73^{b}\pm1.13$	$6.27^{a}\pm1.45$	$5.55^{c}\pm1.32$
D	$7.00^{a}\pm1.34$	$6.18^{b}\pm1.32$	$6.82^{a}\pm1.65$	$6.55^{a}\pm1.21$	$5.73^{c}\pm1.54$
E	$7.36^{a}\pm1.02$	$6.82^{b}\pm1.53$	$6.82^{a}\pm1.21$	$6.91^{a}\pm1.23$	$6.60^{b}\pm1.21$
F	$7.64^{a}\pm1.12$	$6.55^{b}\pm1.50$	$6.91^{a}\pm1.37$	$6.64^{a}\pm1.23$	$7.00^{a}\pm1.65$

Values are means ± standard deviation of triplicate determinations. Means in the same row with different superscript are significantly (P<0.05) different.

Table 8. Mean Sensory Score of Breakfast Cereal Served with Cold Milk

Sample	Appearance	Taste	Mouth feel	Aroma	General Acceptability
A	$7.09^{a} \pm 1.27$	$6.91^{a} \pm 1.44$	$5.91^{b} \pm 1.87$	$6.36^{a} \pm 1.43$	$6.91^{a} \pm 1.30$
B	$6.55^{b} \pm 1.23$	$6.36^{a} \pm 1.72$	$6.00^{a} \pm 1.47$	$6.09^{a} \pm 1.44$	$6.45^{a} \pm 1.75$
C	$7.36^{a} \pm 1.20$	$6.18^{a} \pm 1.47$	$5.18^{b} \pm 1.40$	$5.91^{b} \pm 1.67$	$6.18^{a} \pm 1.35$
D	$7.09^{a} \pm 0.23$	$6.73^{a} \pm 1.27$	$6.36^{a} \pm 1.12$	$6.45^{a} \pm 0.92$	$6.18^{a} \pm 1.60$
E	$6.45^{b} \pm 1.57$	$6.09^{a} \pm 1.82$	$6.18^{a} \pm 1.47$	$5.73^{b} \pm 1.72$	$6.73^{a} \pm 1.32$
F	$7.45^{a} \pm 1.12$	$6.73^{a} \pm 1.19$	$6.64^{a} \pm 1.74$	$6.55^{a} \pm 1.44$	$6.55^{a} \pm 1.34$

Values are means $\pm$ standard deviation of triplicate determinations. Means in the same row with different superscript are significantly ($P<0.05$) different.

4. Conclusion

The study showed that acceptable ready-to-eat breakfast cereals could be produced from yellow maize, soybean and firmly ripe banana flour. Evaluation of the products showed values that the breakfast cereal could serve as good sources of protein, energy, vitamins and minerals. The study also shown that producing breakfast cereals with seed legumes could boost the protein level (up to 18%) in the final products. It also played a role in providing micronutrients like minerals and vitamins, especially Vitamin C which are absent in some commercial products. The drying process employed in the study played a role in reducing the relatively high level of anti-nutrients associated with leguminous food sources and also the moisture content (3 - 4 %). The reduced moisture content limited the micro-flora of the final products to insignificant levels; thereby making the products safe for consumption. Most of the produced breakfast cereals were scored above average by sensory judges. Consumption of the produced breakfast cereal could also help to address the problem of protein-energy malnutrition that is still prevalent in some communities in Nigeria, and most importantly, could improve or encourage the production of more food products containing pro-vitamin A.

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Declarations

Competing Interest

The authors declare no competing interest.

Authors' Contributions

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