

Functional Properties, Nutrient Content, Digestibility and Acceptability of Breakfast Cereals Made from Yellow Maize-Soybean Composite and Firm-Ripe Banana Flour

Edima-Nyah, A. P.; Amande, E. I.; and Ekanem, K. E.

Department of Food Science and Technology, University of Uyo, Uyo, Akwa Ibom State.

Corresponding author: anneedima@uniuyo.edu.ng

DOI: <https://doi.org/10.62154/dz9a7140>

Abstract

Breakfast cereals were produced from blends of yellow maize-Soybean composite and firm-ripe banana flours. A Composite flour blend was formulated by mixing yellow maize flour and soybean flour in the ratio of 70:30. Then, five samples of breakfast cereals were produced by substituting firm-ripe banana flour with the composite flour at the following ratios: 95:5 = A, 90:10 = B, 85:15 = C, 80:20 = D, 75:25 = E, and a 100% composite flour blend of yellow maize and Soybean flour (100:0 = F) served as a control. The functionality of the flour blends was assessed. The breakfast cereals were assessed of their proximate composition, anti-nutrient content, *in-vitro* protein and starch digestibility, and sensory qualities using standard methods. Results revealed that, Bulk density of the samples ranged from 0.90-0.97 g/cm³. Foaming capacity increased significantly from 3.28 to 9.83 %, water absorption capacity increased from 2.60 to 2.40 % while oil absorption capacity decreased from 0.68 to 1.10 % with increased in the percentage composition of firm-ripe banana flour in the blend. Swelling capacity and Gelation temperature ranged from 2.16 to 3.33 % and 72.33 to 75.66 °C respectively. Values of protein (9.31 – 12.65 %), lipid (3.61 – 4.94 %), ash (3.16 – 4.22 %) and calorie (372.85 – 382.76 kcal/100g) decreased, while fibre (2.90 – 4.53 %) and carbohydrate (53.92 – 75.77 %) increased, with increasing substitution of firm-ripe banana flour. Phytate (0.57 to 15.45 mg/100g), tannin (40.25-82.92 mg/100g), oxalate (5.24-8.84 mg/100g) and saponin (3.92 to 10.28 mg/100g) were within safe-limits. *In-vitro* protein digestibility increased from 30.87 to 35.95 % showing significant increase ($p < 0.05$) with increasing substitution of firm-ripe banana flour, while *in-vitro* starch digestibility ranged from 31.74 to 16.21 %. Breakfast cereals developed with up to 10% banana flour compared favourably with Control in all sensory attributes assessed and were acceptable by consumers when served with cold milk.

Keywords: Breakfast Cereals, Yellow Maize, Soybeans, Firm-Ripe Banana, Composite Flour.

Introduction

Breakfast is the first meal of the day eaten after waking up, usually in the morning. The word in English refers to breaking the fasting period of the previous night. There is a strong likelihood for one or more "typical", or "traditional", breakfast menus to exist in most places, but their composition varies widely from place to place, and has varied over time, so that

globally a very wide range of preparations and ingredients are now associated with breakfast. According to CODEX(2005), breakfast cereals are defined as products comprised of cereals that can be taken with milk or other nutrient-rich liquids. A variety of milled cereal products, including wheat, rice, barley, oats, rye, maize, millet, sorghum, and buckwheat, are used to produce cereal-based dishes. For the purpose of completing the protein and diversifying the nutrients, they may also include starchy roots (like arrowroot, yam, or cassava), starchy stems, or oilseeds in lesser concentrations. (Arpita *et al.*, 2011). Changing breakfast habits and demographics across the emerging economies are acting as the major growth drivers for global demand of breakfast cereals. However, the breakfast cereals market is experiencing a slowdown in growth in the recent years due to the increase in consumption of alternative breakfast items and inexpensive breakfast options (Breakfast Cereal Market, 2017).

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). Lysine is an essential amino acid needed by the body for the maintenance of both infants and adult. When cereals are combined with legumes rich in lysine, it supplements for the lysine in cereal (Mbaeyi-Nwaoha and Uchendu, 2016), providing high quality protein that contains essential amino acids in proper proportion, complementing each other. Protein from plant source (legumes) is healthy (Ofuya and Akhidue, 2005).

Among the several cereals, maize (*Zea mays L.*), sometimes known as poor man's nutritive cereal, is a crop with numerous prospects due to its uses in food, feed, and industry; it has the largest energy content (ME 3350 kcal/kg) and is considered as a nutritional cereal (Shiferaw, *et al.*, 2011). Soybean (*Glycine max L.*) contains all the required amino acids in sufficient amounts for growth, maintenance, and reproduction (Omeire *et al.*, 2014). In many parts of the world, it is a staple food. When compared to animal protein, it is the richest, most affordable, and best source of veggie now available to mankind. It has a high proportion of polyunsaturated fat and little saturated fat. Trypsin inhibitor, an anti-nutritional component of soybeans, can be reduced by utilizing the right processing methods, such as sprouting, flaking, and gelatinization, among others. Banana is a fruit of the genus *Musa*, of the family *Musaceae*, one of the most important fruit crops of the world. The banana is grown in the tropics, and, though it is most widely consumed in those regions, it is valued worldwide for its flavor, nutritional value, and availability throughout the year. Mature green banana is a rich source of vitamin B6, moderate amounts of vitamin C, Manganese, Potassium and dietary fibre (Arnarson, 2014). When ripe, banana is usually consumed raw as a fruit dessert, and is a good source of many vitamins (A, B-group, C, E and K), minerals (phosphorus, calcium, magnesium and potassium), carbohydrate and are very rich in fibre (Ogodo *et al.*, 2015). Dessert banana, due to its fibre content, is reported to ease constipation. Also, due to its iron content, it can prevent anemia by stimulating

hemoglobin production (Biernacka *et al.*, 2020). In Africa, over 25% of the total energy required by about 60 million people comes from plantain and banana. Nigeria, as one of the largest banana producers in Africa, accounts for 2.7 million metric tons per year (Olumba and Onunka, 2020). Nevertheless, ripe banana is wasted in tons during the glut season as a result of poor handling processes and insufficient storage facilities.

Therefore, the production of flour from firm-ripe banana would reduce the post-harvest losses of bananas and its utilization in food formulation will thus convert them into useful, acceptable and convenient food products, such as breakfast cereals.

Statement of the Problem

Generally, cereal protein is lacking in some essential amino acids specifically, lysine and tryptophan, which are necessary for growth and development of newborns and young children (Muhimbula, *et al.*, 2014). Regular consumption of foods derived from maize without the addition of high-quality protein foods can cause protein-energy malnutrition as well as the infant disease kwashiorkor (Inyang, *et al.*, 2019). Hence, the need to incorporate soybean in breakfast cereal formulation.

Banana is a climacteric fruit and engages in rapid metabolic processes which leads to ripening and subsequent deterioration and losses, if not eaten immediately. To combat and reduce post-harvest losses in banana fruits during glut periods; conversion of firm-ripe banana to flour, and use in production of value-added food products, will increase its utilization to produce accessible, nutritious and acceptable food products for the populace. This study is thereby focused on the production and evaluation of the nutritional properties of maize-soybean – based breakfast cereals with ways of augmenting and improving the nutrients through further fortification with firm-ripe banana flour.

Objectives of the Study

The main objective is to produce breakfast cereals from blends of yellow maize-soybean composite and firm-ripe banana flours.

The specific objectives of the Study are to:

- a. produce flour from yellow maize, soybean and firmly ripe banana, and formulate composite blends for the production of breakfast cereals.
- b. determine the functional properties of the formulated blends for breakfast cereals production.
- c. determine the proximate composition and the anti-nutrient content of the breakfast cereals.
- d. evaluate protein and starch digestibility, and sensory qualities of the breakfast cereals.

Materials and Methods

Procurement of Raw Materials

Yellow maize grain (*Zea mays*), Soya beans (*Glycine max*), mature, ready to ripen, banana (*Musa sapientum*), sugar and salt were purchased at Etaha Itam 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.

Sample Preparation

The yellow maize grain was properly sorted and cleaned to remove extraneous material like dust, stones, dirt, chaff, defected grains and other unwanted material prior to 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 properly peeled before they were used for further processing.

Processing of Yellow Maize Flour

The method used was a modification of the method described by Sulaiman *et al.*, (2018). 2 kg of yellow maize was cleaned and sorted. It was washed and dried in the oven at 60°C for 24 hours after which it was milled into flour. The process flow chart for the production process is shown in Figure 1.

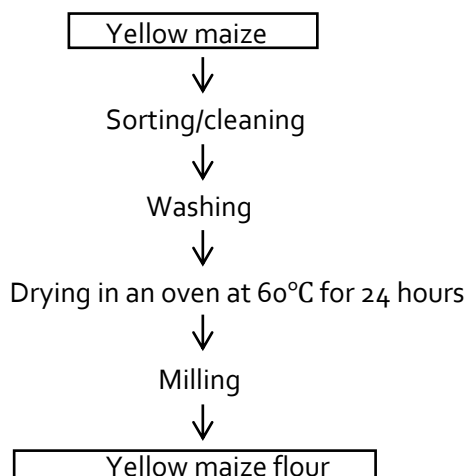


Figure 1: Flow diagram of maize milling

Source: Sulaiman (2018)

Production of Soy Beans Flour

The soybean flour was prepared according to the method described 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 a hot air oven at 80°C for 18 hours. The soybean was then milled to get flour. The soybean flour was sieved through a 425-micrometer pore screen and packaged in an airtight plastic container (Fig. 2), labeled and stored at ambient temperature ($27\pm2^{\circ}\text{C}$) for subsequent use a fine product.

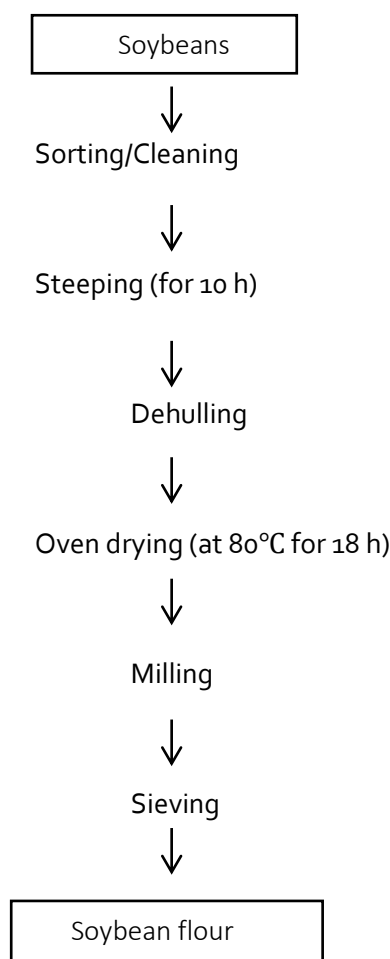


Figure 2: Modified flow diagram for the production of soybean flour

Source: Bolarinwa *et al.* (2016)

Production of Banana Flour

The method used for the production of banana flour was modified from the process described by (Ezeokeke and Onuoha 2016). The bananas were washed with clean water, peeled manually, cut into slices of about 5mm thickness, and dipped in 0.5% metabisulphite solution for 5 Mins to prevent browning. It was dried in an oven for 12 hours at 60°C, milled and sieved into fine flour. The flour was packaged in an airtight plastic container, labeled and stored at ambient temperature ($27\pm2^{\circ}\text{C}$) for further use. The process flow chart for the production process is shown Figure 3.

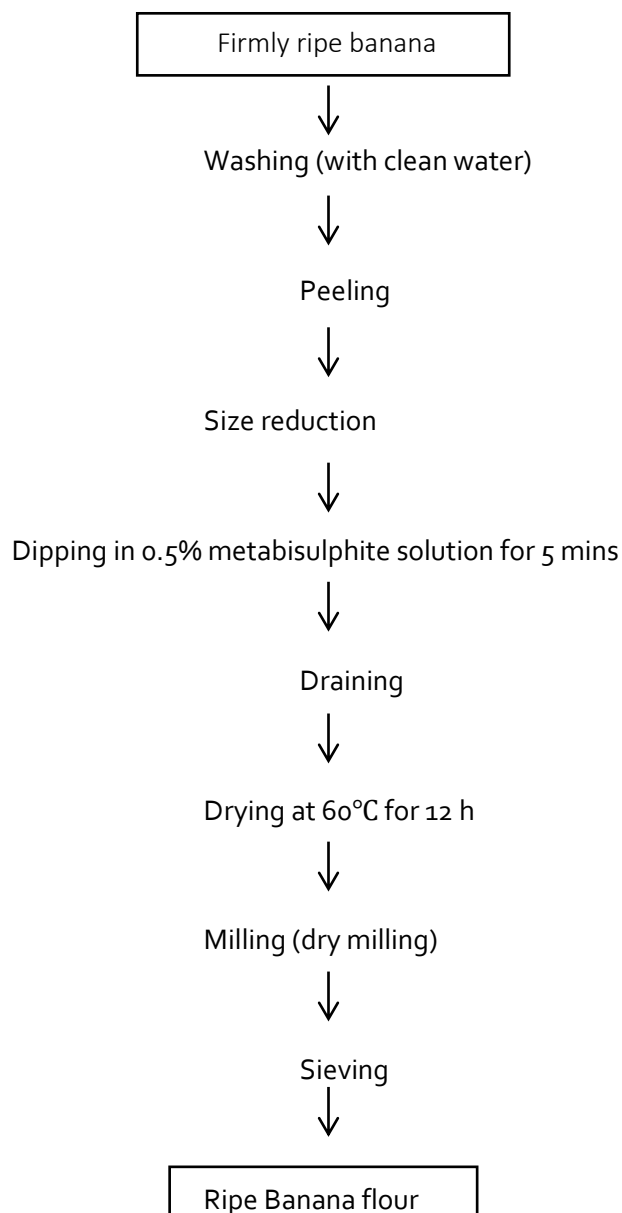


Figure 3: Modified from Flow diagram for the production of Banana Flour
Source: Ezeokeke and Onuoha (2016).

Product Formulation of Composite Flour Blends

Composite flour blend was formulated by mixing yellow maize flour and soybean flour (70:30), five samples of breakfast cereals was produced by mixing the composite flour (made of Yellow maize and Soybean flour) with firm ripe Banana flour at the ratios of 95:5= A, 90:10 =B, 85:15 = C, 80:20 = D, 75:25 = E (Table 1) and a control sample of 100% original composite flour blend of Yellow maize and Soybean flour cereal was used (100:0 = F). The

recipe used for the production of breakfast cereals, according to Edima-Nyah *et al.* (2020) included 56g of sugar, 4g of salt, 200ml of water, for 400g of flour.

Table 1: Composite flour formulation for breakfast cereals made from yellow maize-Soybean (YM-SB) composite and firm ripe Banana (BN) flours

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

Edima-Nyah *et al.* (2020)

Production of Breakfast Cereals

Composite flour was formulated by mixing yellow maize flour, Soybean flour and Banana flour using the method described by (Okafor and Usman 2014). Five (5) samples of breakfast cereals were produced by mixing the composite flour in different proportions; 95:5, 90:10, 85:15, 80:20, 75:25. Sugar and salt were added to taste and mixed manually very thoroughly. The dough obtained was kneaded on a flat surface and passed through a Euroson Globe150 cold extruder (model: MC-8830) using the snack forming die. The extruded dough was placed in an oven (NAAFCO BS Oven, model: OVH-102) and toasted at 80°C for 2 hours until a dry crisp breakfast cereal was obtained. The products were allowed to cool and packaged in airtight containers, labelled and used for various analysis. Figure 4 describes the production of breakfast cereal. Photographs of the flour samples and breakfast cereals produced are shown in Plate 1.

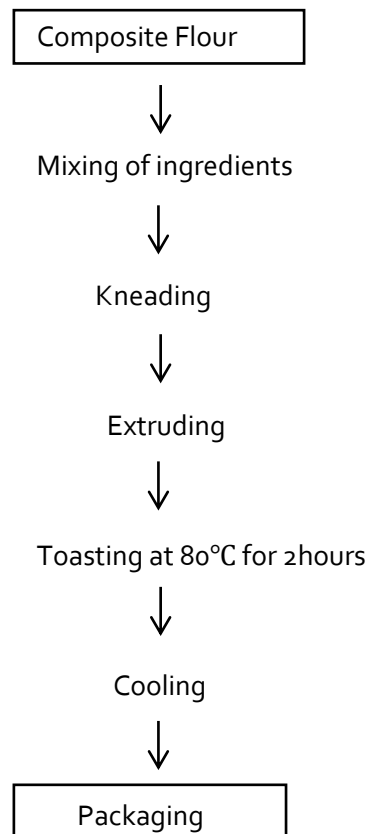


Fig. 4: Flow chart showing the Production of Breakfast cereal from blends of yellow maize, soybean and firmly ripe banana.

Source: Okafor and Usman (2014).



Plate 1: Photographs of Breakfast Cereals Produced from yellow maize-soybean and firm ripe banana flour blends

Sample A= 95:5 (YM-SB: BN), **Sample B**= 95:5 (YM-SB: BN), **Sample C**= 85:15 (YM-SB: BN), **Sample D**= 80:20 (YM-SB:BN), **Sample E**= 75:20 (YM-SB:BN), **Sample F (control)**= 100:0 (YM-SB:BN)

Analytical Procedures

Determination of Functional Properties of Flour Blends

Bulk Density Determination

Bulk density was determined by the method described by Onwuka (2005). A weighed centrifuge tube of 10ml was filled with 10ml of the sample and the weight was recorded. This was subjected to a constant tapping in the volume which was observed and then the final weight was taken. The difference in weight was used to calculate the bulk density of the samples.

$$\text{Bulk density} = \frac{\text{Weight of sample(g)}}{\text{Volume of sample (ml)}}$$

Foaming Capacity Determination

Foaming capacity was determined using the method described by Onwuka (2005). Two grams (2g) of finger millet-Bambara groundnut composite flour sample was added to 50ml of distilled water at $30 \pm 2^\circ\text{C}$ in a 100 ml graduated cylinder. The suspension was mixed and

shaken manually for 5min to foam. The volume of foam at second after whipping was expressed as foaming capacity using the formula;

$$\text{Foam capacity} = \frac{\text{volume of foam after mixing} \times 100}{\text{volume of mixture}}$$

Water and Oil Absorption Capacities Determination

Water and oil absorption capacities were determined according to the method of Onwuka (2005). One gram of the sample was weighed into a clean conical graduated centrifuge tube and was thoroughly mixed with 10ml of distilled water/oil for 30 seconds. The sample was allowed to stand for 30 minutes at room temperature after which it was centrifuged at 5,000 rpm for 30 minutes. After centrifugation, the volume of the supernatant, water/oil was read directly from the graduated centrifuge tube. The absorbed oil/water was converted to weight (in grams) by multiplying by the density of oil (0.894/ml) and water (1g/ml) respectively. The oil and water absorption capacities were expressed as grams of oil/water retained per gram of sample used.

$$\% \text{ Water/Oil Absorption} = \frac{\text{ml of water absorbed}}{\text{weight of sample}} \times \frac{100}{1}$$

Swelling Capacity Determination

Swelling capacity was determined according to the method described by Abbey and Ibeh (1988). Exactly 1 g was weighed into a 10ml graduated measuring cylinder. Exactly 5ml of distilled water was carefully added and the volume occupied by the sample was recorded. The samples were allowed to stand undistributed in water for 1 hour and the volume was again recorded.

$$\text{Swelling capacity (\%)} = \frac{\text{volume occupied by sample after swelling}}{\text{volume occupied by sample before swelling}}$$

Gelatinization Temperature

Gelatinization temperature was determined using the procedure of Onwuka, (2005). Ten (10) grams of the sample was suspended in distilled water in a 250ml beaker and made up to 100ml sample suspension. The aqueous suspension was heated in a boiling water bath with continuous stirring using a stirrer. A thermometer was then clamped on the retort stand with its bulb submerged in the suspension. The heating and stirring continued until the suspension began to gel and the corresponding temperature was recorded.

Determination of Proximate composition and Calorific Value of Breakfast cereals

Proximate composition of breakfast cereals was determined using standard methods of AOAC (2005) for moisture, protein, lipid, ash, crude fibre and carbohydrate content. Calorific values were estimated by calculation using the water quantification factors of 4,9

and 4 kcal/100g of protein, fat and carbohydrate respectively as described by Osborne and Voogt (1978), and expressed in the equation below:

Calorific value (kcal/100g) = $P \times 4 + F \times 9 + C \times 4$.

Where: P=Protein (%), F= Fat content (%), C=Carbohydrate content (%)

Determination of Anti-Nutrient Content of Breakfast Cereals

Phytate and tannin content of breakfast cereals were determined by the standard methods described by Onwuka (2005), while oxalate and saponin contents were determined by the solvent extraction gravimetric method instituted by AOAC (2005).

Determination of *In-Vitro* Protein Digestibility (IVPD)

The method of Kanu *et al.*, (2009) was used with slight modifications. The breakfast cereals (5 g each) were placed in a 50 mL centrifuge tube, to which 15 mL of 0.1N HCl containing 1.5 mg pepsin-pancreatin was added and the tube was incubated at 37°C for 3 h. The suspension was then neutralized with a phosphate buffer (pH 8.0), containing 0.005 M sodium azide. 1 ml of toluene was added to prevent microbial growth and the mixture was gently shaken and incubated for an additional 24 h at 37°C. After incubation the sample was treated with 10 mL of 10% Trichloroacetic Acid (TCA) and centrifuged at 5000 rpm for 20 min at room temperature. The protein in the supernatant liquid was estimated using the Kjeldahl method. The percentage of protein digestibility was calculated using the following formula:

$$\text{Protein Digestibility (\%)} = \frac{\text{protein in supernatant}}{\text{protein in sample}} \times 100$$

Determination of *In-Vitro* Starch Digestibility

In-vitro Digestibility of starch was determined following the method of Singh *et al.*, (2012). Exactly 50 mg each of breakfast cereals were weighed into test tubes and mixed with 1 ml of 0.2 M phosphate buffer (pH 6.9). Pancreatic α -amylase (0.5 ml; 20 mg enzyme dissolved in 50 ml of the same buffer) was added to the sample mixtures and incubated at 37°C for 2 h. After incubation, 2 ml of 3,5-DNS reagent (prepared by dissolving 200 mg crystalline phenol, 1 g of 3,5-dinitrosalicylic acid and 50 mg sodium sulphite in 1 % NaOH solution) was added immediately. The mixture was heated for 5-15 min in a boiling water bath. Exactly 1 ml of K-Na Tartarate solution was added to the mixture test tubes and allowed to cool at 25°C. The solution was therefore made up to 25 ml with distilled water and filtered prior to reading of the absorbance at 550 nm. A blank was run simultaneously. A standard curve was prepared using maltose and values obtained were expressed as mg maltose equivalent per 100 mg of sample.

Sensory Evaluation of Breakfast Cereal

Sensory evaluation of the breakfast cereals made from yellow maize-soybean and firm ripe banana composite flour was conducted using twenty (20) semi trained panel members drawn from the Department of Food Science and Technology, University of Uyo, Akwa-

Ibom State. The breakfast cereal samples were coded and presented in identical containers and served with cold milk for the evaluation. Water was provided for cleaning the mouth in-between each sample testing to prevent the transfer of sensory attributes from one sample to the other. Sensory attribute evaluated included appearance, taste, flavour, mouthfeel, and overall acceptability, using a nine-point hedonic scale as described by Iwe (2002). All panelists were conversant with the attributes of breakfast cereals.

Statistical Analysis

All the data generated in this study were in triplicates, and 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.

Results and Discussion

Functional Properties of Flour Samples for Production of Breakfast Cereals

Results of bulk density, foaming capacity, water and oil absorption capacity, swelling capacity and gelatinization temperature are shown in Table 2. Values for bulk density of flour blends for used for breakfast cereals production ranged from 0.90 to 0.97 g/m³. Bulk density of flours is density measured without consideration of any external force or compression (Chandra *et al.*, 2015), and can be used to assess the weight of flour, handling requirements, and the kind of packaging material appropriate for food products storage and transportation (Oppong *et al.*, 2015). Thus, less the bulk density, the more packaging space is required. Foaming capacity of flour blends (3.28 – 9.83 %) increased with increasing addition of banana flour. These values are lower than the values of 10.40% to 18.17% reported by Iwe *et al.* (2016) for African yam beans and cowpea seeds flour blends; probably because the two food materials were protein sources. Foamability has been reported by Foegeding *et al.* (2006) to be related to the number of solubilized proteins and the amount of polar and non-polar lipids in the sample.

Water absorption capacity of the flour blends ranged from 2.06 – 2.40 %, and increased with increasing addition of banana flour. The ability of flour to absorb water raises the possibility that it might be used in the preparation of some foods, including dough, sausages, and bakery goods (Chandra *et al.*, 2015). Oil absorption capacity decreased (0.68 – 1.16 %) with increased banana. Higher values (0.87 – 1.32%) was recorded for breakfast cereals from blends of maize, African Yam Bean, sorghum extract and coconut flour by Okafor and Usman (2015). Oil acts as flavour retainer and also increases mouth feel and over all palatability of food. It is an indication of the rate at which protein binds to fat in food formulation (Amandikwa *et al.*, 2015).

Swelling capacity ranged from 2.16% to 3.33 %. The ability of flour to swell during heating is a sign that granules have absorbed water (Ikegwu *et al.*, 2010), and is connected to the starch's amylose-amylopectin ratio, where a high swelling power is caused by a low amylose

and high amylopectin concentration (Adebowale *et al.*, 2005). Gelatinization temperature of the flour blends ranged from 72.33 °C to 75.66 °C, which decreased with decrease in yellow maize-soybean content, with the highest value observed in the control (sample F). However, there was no significant ($p>0.05$) differences in samples C, D and E. The values obtained in the present study were comparable to values (75.32- 89.66 °C) reported by Okafor and Usman, (2014) for breakfast cereal from blends of maize, African yam bean and defatted coconut cake. A gel is a phase in between the solid and liquid phases. Proteins, polysaccharides, or a combination of the two make up the chemical web in food systems, while water is typically the liquid. The properties of gelatin can be affected by ionic strength, pH, and the existence of non-protein components (Sridaran *et al.*, 2012).

Table 2: Functional properties of blends of maize-soybean and firm-ripe banana flours for breakfast cereal production

Sample	Bulk Density (g/cm ³)	Foaming Capacity %	WAC %	OAC %	Swelling Capacity %	GT (°C)
A	0.95 ^{bc} ±0.00	3.53 ^e ±0.04	2.23 ^{ab} ±0.05	1.10 ^a ±0.00	3.16 ^a ±0.20	74.73 ^b ±1.53
B	0.90 ^f ±0.00	3.76 ^d ±0.02	2.30 ^a ±0.00	1.10 ^a ±0.00	3.00 ^{ab} ±0.00	74.67 ^b ±0.57
C	0.92 ^{de} ±0.00	7.54 ^c ±0.05	2.33 ^a ±0.05	1.10 ^a ±0.00	3.00 ^{ab} ±0.00	73.33 ^c ±0.50
D	0.94 ^{cd} ±0.00	9.63 ^b ±0.04	2.36 ^a ±0.05	1.06 ^a ±0.05	2.16 ^b ±0.20	73.33 ^c ±0.38
E	0.96 ^{ab} ±0.00	9.83 ^a ±0.03	2.40 ^a ±0.10	0.68 ^b ±0.57	2.16 ^b ±0.28	73.33 ^c ±0.58
F	0.97 ^a ±0.01	3.28 ^f ±0.04	2.06 ^b ±0.05	1.16 ^a ±0.05	3.33 ^a ±0.57	75.66 ^a ±1.04

Values are mean ± SD of 3 replicate determinations. Means differently superscripted in the columns are significantly different ($p<0.05$). A = 95:5, B = 90:10, C = 85:15, D = 80:20, E = 75:25 and F = 100:0 (control) for yellow maize- soybean: ripe banana blends respectively.

KEY

WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, GT = Gelatinization Temperature

Proximate Composition and Calorific Values of Breakfast Cereals Produced from Yellow Maize-Soybean Flour Blends and Firm-Ripe Banana Flour

Results of proximate composition and calorific value of breakfast cereals produced from maize-soybean composite flour and firm-ripe banana flour is as presented in Table 3. Moisture content of snack bars was low, ranged from 3.36 – 3.61 %, which was of advantage since it could reduce the incidence of growth of microorganism (bacteria, in particular), thereby improving shelf stability. Protein content decreased significantly ($p < 0.05$) from 9.31 to 12.65 % This range was close to the values reported (9.25- 14.75 %) by Edima-Nyah *et al.*, (2019) for yellow maize, soybean and unripe banana-based breakfast cereal. This protein level is therefore contributed by the soybean flour, and could be used to alleviate the problem of protein – energy malnutrition that is still prevalent in developing countries like Nigeria (Inyang *et al.*, 2018). Lipid value ranged from 3.61 to 4.94 %, and decreased significantly ($p < 0.05$) with decreased yellow maize-soybean composite blend. Mbaeyi-Nwaoha and Uchendu, (2016) reported a higher range of 11.57 to 16.29 % fat. Low fat content of these products could be beneficial to individual interested in watching their weight (Agunbiade and Ojezele, 2010). Ash content increased with increase in the percentage composition of yellow maize-soybean flour. 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 study materials. Fibre (2.90 – 4.53 %) and carbohydrate (53.92 – 75.77 %) content of breakfast cereals increased with decreasing addition of maize-soybean and increase addition of banana flour in the blend. Bananas are a rich source of fibre and carbohydrate, mainly starch, which are converted to sugars on ripening. The carbohydrate values in this work are higher than those recorded by Usman *et al.* (2015) in breakfast cereals (60.96 – 64.53 %) produced from local rice, soybean and defatted coconut flours.

Caloric (energy) value of breakfast cereals ranged from 372.85 to 382.76 (Kcal/100g) and decreased with increasing addition of banana flour in the formulation, and a corresponding decrease in fat content. These values represent the 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). Highest values of protein (12.65%), lipid (4.94%), ash (4.22%) and calorific value (382.76kcal/100g) was observed in sample F (Control, 100% yellow maize-soybean composite), and was followed closely by sample A (95% yellow maize-soybean composite and 5% firm-ripe banana flours).

Table 3: Proximate composition and Energy values of breakfast cereals produced from yellow maize-soybean blends and firm-ripe banana flour

Sample	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	Calorific value (Kcal)
A	3.58 ^a ±0.01	12.25 ^b ±0.50	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	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	3.45 ^b ±0.01	10.92 ^d ±0.20	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	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 ^a ±0.06	374.47 ^d ±0.29
E	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	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 mean ± SD of 3 replicate determinations. Means differently superscripted in the columns are significantly different ($p < 0.05$). A = 95:5, B = 90:10, C = 85:15, D = 80:20, E = 75:25 and F = 100:0 (control) for yellow maize- soybean: ripe banana blends respectively.

Anti-Nutrient Properties of Breakfast Cereal Formulated from Yellow Maize-Soybeans and Firm-Ripe Banana Flours

Results of Phytate, tannin, oxalate and saponin content of breakfast cereals produced from yellow maize-soybean composite and firm ripe banana flours are presented in Table 4. Phytate content ranged from 0.57 to 15.45 mg/100g and increased significantly ($p < 0.05$) with increasing banana substitution. Edima-Nyah *et al.*, (2020) recorded phytate values ranging from 8.18 to 9.90 mg/100g for breakfast cereals from yellow maize, soybean and unripe banana. The level of phytate in the breakfast cereals was lower than the maximum acceptable/safe limits 250 mg/100g (Nagel, 2010). The reason for the general low value could be attributed to the processing method applied. Mechanical processing such as milling and polishing and enzymatic degradation of inhibitors could help remove phytic acid and fiber (Gibson *et al.*, 2000).

Tannin values ranged from 40.25 to 82.92 mg/100g, and significantly ($p < 0.05$) increased with increasing ripe banana addition. The values were lower than the safe level (90 mg/100g) (Maseta *et al.*, 2016). This is very important because higher tannin content could make proteins unavailable for human nutrition. Earlier researches suggested that protein-tannin complex appeared to be formed by multiple hydrogen bonding between phenolic hydroxyl groups of tannins and carbonyl groups of protein peptide bonds of digestive enzymes, inhibiting proteolytic enzyme activity in the gastro-intestinal tract (Ogunwolu *et al.*, 2015). Thus, tannins reduced the protein digestibility by inhibiting the digestive

enzymes, and sometimes gives food a dark colour due to its reaction with iron, and can equally provoke an astringent reaction in the mouth, making the food unpalatable.

Oxalate content ranged from 5.24 to 8.84 mg/100g. The least oxalate value was observed in sample A formulation and the highest oxalate value was observed in sample E formulation. Usman *et al.* (2015) observed a lesser oxalate value (0.47-1.47 mg/100g) in breakfast cereals made from mixtures of local rice, soybean, and coconut flour. All the breakfast cereals produced could be considered safe for human consumption, since the concentration of oxalate in them could not be toxic under meal portion, as the safe level in man is 15-30g/100g food consumed (Coe *et al.*, 2005). This is important because, oxalate, when present in the body, combines with divalent cations of iron and calcium to form their insoluble salts. These salts cause obstructions in the kidney tubules and consequently lead to the formation of kidney stones (James and Nwabueze, 2013).

Saponin content for the breakfast cereals showed a range from 3.92 to 10.28 mg/100g, decreasing significantly with increased ripe banana and decreased yellow maize-soybean flour. Bolarinwa *et al.* (2015) recorded 1.41 to 3.13 mg/100g range of values in complementary diets made with malted millet, soybean and plantain flour blends. Although legumes contain a wide range of toxic components, the effects of most of these components are small or negligible in a mixed diet especially when legumes are properly cooked. Because saponin has been shown to change cell wall permeability and cause some toxic effects when consumed, lowering its levels has tremendous health benefits. Saponin has both beneficial and adverse effects on human health. Apart from their hypocholesterolemic properties, saponin also shows hemolytic activity by reacting with the sterols of erythrocyte membrane (Bauman *et al.*, 2000).

Table 4: Anti-nutritional content of breakfast cereals produced from yellow maize-soybeans and firm-ripe banana flour blends

Sample	Phytate (mg/100g)	Tannin (mg/100g)	Oxalate (mg/100g)	Saponin (mg/100g)
A	2.65 ^e ±0.02	46.78 ^e ±0.01	5.24 ^e ±0.04	5.51 ^b ±0.01
B	4.25 ^d ±0.05	49.06 ^d ±0.01	5.53 ^d ±0.03	5.22 ^b ±0.02
C	9.58 ^c ±0.02	54.78 ^c ±0.00	5.55 ^d ±0.05	4.24 ^c ±0.03
D	13.31 ^b ±0.50	63.46 ^b ±0.00	7.12 ^b ±0.02	4.04 ^c ±0.04
E	15.45 ^a ±0.04	82.92 ^a ±0.01	8.84 ^a ±0.04	3.92 ^d ±0.02
F	0.57 ^f ±0.04	40.25 ^f ±0.01	6.05 ^c ±0.04	10.28 ^a ±0.03

Values are mean ± SD of 3 replicate determinations. Means differently superscripted along the vertical columns are significantly different (P<0.05).

A = 95:5, B = 90:10, C = 85:15, D = 80:20, E = 75:25 and F = 100:0 (control) for yellow maize-soybean: ripe banana blends respectively.

***In-Vitro* Protein and Starch Digestibility of Breakfast Cereals Produced from Yellow Maize-Soybean Composite and Firm-Ripe Banana Flours**

Results for *in-vitro* protein and starch digestibility of breakfast cereals produced from yellow maize-soybean composite and firm-ripe banana flours are presented in Table 5. Protein quality can be assessed using *in-vitro* protein digestibility, which is also a good indicator as to how bioavailable proteins are in food. Breakfast cereal made from a combination of yellow maize, soybeans, and firm-ripe bananas had significantly ($p < 0.05$) different *in-vitro* protein digestibility from one another. The *in-vitro* protein digestibility values of the breakfast cereals obtained in this study ranged from 22.85 to 35.95 % while Hooda *et al.*, (2005) reported the values of 37.2 to 70.8 % in wheat-fenugreek biscuits. The values presented in this study were also lower than values reported by Edima-Nyah *et al.*, (2020) which showed a range of values 80.46 to 86.44 % of *in vitro* protein digestibility in breakfast cereals produced with yellow maize, soybean and unripe banana flour blends, this could have been as a result of different processes or the presence of certain anti nutrients.

In-vitro starch digestibility of the breakfast cereals ranged from 16.21 to 33.78 % and decreased significantly ($p < 0.05$) with increase addition of firmly ripe banana flour. Lower values (11.6 – 13.4 %) of IVSD were reported by Flores-Silva (2015) for snacks from unripe plantain, chickpea and maize flour blends, and 4.65-mg/g starch digestibility for multi-millet extruded snacks (Wadikar *et al.*, 2014). James and Nwabueze (2013) also reported lower values of *in vitro* starch digestibility (27.45 -28.23 %) in extruded African breadfruit-soy based snacks.

According to Singh *et al.* (2010), The individual interactions between starch and protein in any meal have a significant impact on how easily they can be absorbed. Research suggests that the amount of protein in the cereal product may have an impact on how easily starch is digested.

The low moisture level of the product may have limited the gelatinization of the starch, reduced the hydrolysis of the amylase, and thus decreased the starch digestibility of the breakfast cereals with increased addition of firm ripe banana flour.

Table 5: *In-vitro* protein and starch digestibility of breakfast cereals produced from yellow maize-soybean composite and firm-ripe banana flours

Sample	IVPD (%)	IVSD (%)
A	30.87 ^e ±0.01	31.74 ^b ±0.01
B	32.63 ^d ±0.03	28.74 ^c ±0.01
C	32.81 ^c ±0.01	26.76 ^d ±0.02
D	35.66 ^b ±0.01	23.97 ^e ±0.5
E	35.95 ^a ±0.03	16.21 ^f ±0.02
F	22.85 ^f ±0.01	33.78 ^a ±0.00

Values are mean ± SD of 3 replicate determinations. Means differently superscripted along the vertical columns are significantly different ($p < 0.05$).

A = 95:5, B = 90:10, C = 85:15, D = 80:20, E = 75:25 and F = 100:0 (control) for yellow maize-soybean: ripe banana blends respectively.

Sensory Qualities of Breakfast Cereal Served with Milk

Mean scores of sensory attributes of breakfast cereals served with cold milk is represented in Table 6. The control, Sample F (100% yellow maize-soybean and 0% banana), had the highest mean score in appearance (7.45) and aroma (6.55). This could be as a result of the absence of banana flour, which had a dark colouration, probably due to oxidative or maillard reaction. Sample A (95% yellow maize-soybean and 5% banana) competed favourably with sample F (Control), in all sensory attributes assessed, and ranked highest in taste (6.91), mouthfeel (6.91) and overall acceptability (6.91). There was no significant difference in the taste and overall acceptability of all the breakfast cereals formulated. This signify that acceptable breakfast cereals could be developed with up-to 25% firm-ripe banana inclusion.

Table 6: Mean Sensory Score of Breakfast Cereals produced from yellow maize- soybean and firm-ripe banana flour, Served with Cold Milk

Sample	Appearance	Taste	Mouthfeel	Aroma	Overall Acceptability
A	7.36 ^a ± 1.27	6.91 ^a ± 1.44	6.91 ^a ± 1.87	6.46 ^a ± 1.43	6.91 ^a ± 1.30
B	7.09 ^a ± 1.23	6.36 ^a ± 1.72	6.00 ^a ± 1.47	6.09 ^a ± 1.44	6.45 ^a ± 1.75
C	7.09 ^a ± 1.20	6.18 ^a ± 1.47	5.18 ^b ± 1.40	5.91 ^b ± 1.67	6.18 ^a ± 1.35
D	6.55 ^b ± 0.23	6.73 ^a ± 1.27	6.36 ^a ± 1.12	6.45 ^a ± 0.92	6.18 ^a ± 1.60
E	6.35 ^b ± 1.57	6.09 ^a ± 1.82	6.18 ^a ± 1.47	5.73 ^b ± 1.72	6.13 ^a ± 1.32
F	7.45 ^a ± 1.12	6.73 ^a ± 1.19	6.64 ^a ± 1.74	6.55 ^a ± 1.44	6.75 ^a ± 1.34

Means differently superscripted along the vertical columns are significantly different ($P < 0.05$).

A = 95:5, B = 90:10, C = 85:15, D = 80:20, E = 75:25 and F = 100:0 (control) for yellow maize - soybean: ripe banana blends respectively.

Conclusion

This study showed that acceptable breakfast cereals could be produced from composite blends of yellow maize and soybean flours, with firm-ripe banana flour. Substitution of composite of yellow maize and soybean flours with firm-ripe banana flour resulted in enhanced water absorption and swelling capacities of the flour blends. The results obtained from this study have also indicated that breakfast cereals developed could be safe for human consumption, with permissible levels of anti-nutrients. Protein, lipid, ash and calorific value decreased, while fibre and carbohydrate content increased with substitution of banana flour in the formulation. There was no significant difference between the control (sample F) and sample A and B in all sensory attributes assessed (appearance, taste, aroma, mouthfeel, overall acceptability). Up to 10% banana flour substitution produced breakfast cereals with good nutrient mix, protein and starch digestibility and consumer acceptability. The research work was able to address post-harvest lost in banana by way of processing, as well as improving the nutrients of the produced breakfast cereals through further fortification with firm-ripe banana flour. Further studies show be carried out on the shelf life of the products

Recommendations

Based on the research findings, it is recommended that;

1. Food industries involved in production of breakfast cereals could adopt the inclusion of 10% firm-ripe banana flour, in maize-soybean composite blend for their formulation. This could give a new variety for consumer choice and preference, and equally reduce dependence on importation of expensive wheat.
2. Further research should be done on mixture/process design to improve protein and starch digestibility of the breakfast cereals.

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