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Functional Properties and Chemical Composition of Composite Flour Made from Cooking Banana (*Musa Paradisiaca*) and Yellow Maize (*Zea Mays*)

A. I. Asouzu[1], N. M. Oly-Alawuba[2*] and N. N. Umerah[3]

[1]*Ignatius Ajuru University of Education, Port Harcourt, Nigeria*
[2]*Department of Nutrition and Dietectics, Imo State University, Owerri, Nigeria*
[3]*Department of Food Science and Technology, Enugu State University of Science and Technology, P.M.B. 01660, Enugu, Nigeria*

***Corresponding Author:** Oly-Alawuba, Department of Nutrition and Dietectics, Imo State University, Owerri, Nigeria*

ABSTRACT

Cooking banana is an underutilized crop, high in fibre and important in the management of diabetes. Maize on the other hand, is one of the widely grown cereals and cash crop in Nigeria. The study was carried out to determine the functional properties and chemical composition of cooking banana and yellow maize flour blend. Cooking banana and yellow maize were processed and milled into flour. The samples were coded as follows: A = 100% Yellow Maize Flour, B= 90:10 Yellow maize and cooking banana flour, C= 80:20 Yellow maize and cooking banana, D= 70:30 Yellow maize and cooking banana, E=60:40 Yellow maize and cooking banana and F 100% cooking banana. All the samples were subjected to laboratory analysis for proximate, minerals and functional properties using standard methods. Data was subjected to analysis of variance (ANOVA) and mean was separated using Duncan New Multiple Range (P<0.05).The results were; 2.20-4.20%, 2.10-6.20%, 0.82-4.21%, 2.23-4.21%, 8.20-13.10 and 74.05-80.07% for protein, fat, Ash, fibre, moisture and carbohydrate respectively. The mineral contents were; 4.02-12.20mg, 0.86-130.40mg, 39.14-90.65mg, 1.38-2.06mg, 120.53-163.15mg, 10.20-24.70mg and 67.48-130.43mg/100g for iron, calcium, phosphorus, zinc, magnesium, sodium and potassium respectively and the functional properties for the samples were0.63-0.78g/ml, 137.67-175.42g/g, 110.24-130.66g/g, 2.30-2.68% and 3.08-5.00v/v for bulk density, WAC, OAC, foam capacity and swelling capacity respectively. The study revealed the production of nutrient dense composite flour from blends of yellow maize and cooking banana flour.

Keywords: *Yellow maize, cooking banana, functional properties, composite flour.*

INTRODUCTION

The use of composite flour has been identified by researchers as a possible avenue of producing high-quality nutritious food products, reduced celiac diseases and a means of reducing the huge amount of foreign exchange spent by Nigeria in the importation of wheat flour Olaoye et al., (2013), Nwosu, (2013) and Vaugha et al., (2014).

Cooking bananas, otherwise known as *Musa paradisiaca* Redhead (1989) are banana cultivars whose fruits are generally used in cooking. They may be eaten while ripe or unripe and are generally starchy Luis et al., (2012), Alon, (2014) and Claire, (2014). Some cooking bananas are also referred to as ‘green bananas or plantains’ Robin, (2000). The term “plantain” is used only for “true” plantains, while other starchy cultivars also used for cooking are called “cooking bananas” cronauer and krikorian (1984), valmayor et al.,(2000). Banana are rich source of minerals, vitamins, polyphenols, resistant starch, and anti-oxidants Jaurez-Gracia et al.,(2006).Vergara Valencia et al.,(2007)..

Maize, also known as corn; botanically called *Zea mays*, is a cereal grain first domesticated by indigenous people in southern Mexico about 10,000 years ago The Evolution of corn,(2016). Maize has become a staple food in many parts of the world, with total production surpassing that of wheat or rice. The six major types of corn are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn (yellow maize) Frankin, (2013). Maize contains moderate amounts of dietary fiber, magnesium and phosphorus whereas proteins are in low amounts of the essential amino acids which amounts for its lower status as a protein source Solon Robinson, (1853).

Substitution of wheat with yellow maize and cooking banana is meant to reduce celiac disease among the gluten intolerance people, lead to food security and improve the nutritional status of the consumers. The aim of this study was to determine the functional properties and chemical composition of composite flours made from cooking banana and yellow maize.

MATERIALS AND METHODS

Source of Raw Materials

Two kilogram (2kg) of yellow maize (*Zea mays*) seed, 1.5 kg of cooking banana and 500g of processed wheat flour were purchased from Ogbete Main Market Enugu, Nigeria.

Production of Cooking Banana Flour

The green bananas were peeled, chopped, dried and milled Ovando Martinez,(2009).One and half kilogram of green banana were washed with deionized water, peeled, sliced into smaller pieces, soaking in 0.5% sodium metabisulphite for 5 minutes, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50°C for 24 h with occasional stirring of the slices at intervals of 30 mins to ensure uniform drying and ground into flour using attrition mill (Model Globe P44, China). The flour samples were passed through a 0.45mm mesh size sieve. It was then packaged in an air tight polyethylene bag, stored in a plastic container with lid and kept in a freezer until needed for analysis.

Processing of Cooking Banana Flour

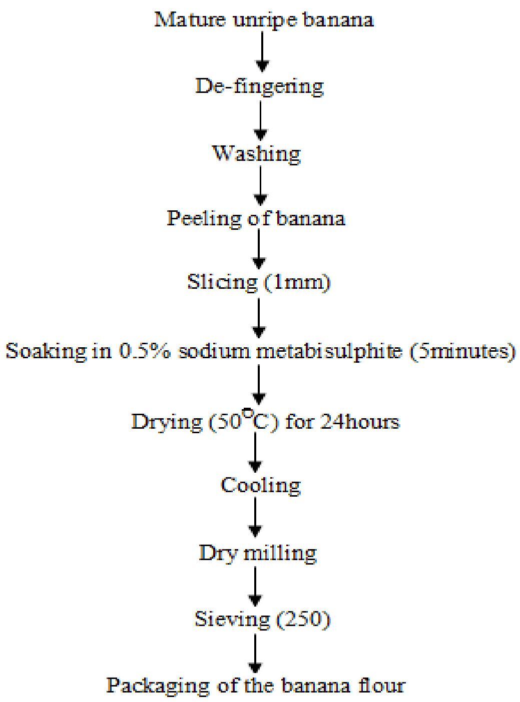

Figure1. *Flowchart for cooking banana flour preparation*

Source: *(Daramola and Osanyinlusi, 2006)*

Production of Maize Flour

Maize was thoroughly cleaned by picking out all broken kernels together with other foreign particles and then sorted to obtain the wholesome ones. Then 1kg of maize kernels were washed, soaked in 10 L of water and allowed to stand for 72 hours at room temperature (27°C).The maize were spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50°C for 24 h with occasional stirring at intervals of 30 mins to ensure uniform drying and ground into flour using attrition mill (Model Globe P44, China). The flour samples were passed through a 0.45mm mesh size sieve. It was then packaged in an air tight polyethylene bag, stored in a plastic container with lid and kept in a freezer until needed for analysis.

Processing of Maize Flour

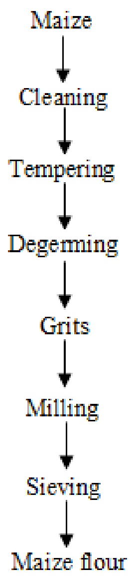

Figure2. *Flow diagram of maize flour preparation*

Source: *(Houssou and Ayenzor, 2002)*

Formulation of Composite Blends

Maize and cooking banana flours were thoroughly mixed together at varying proportions of 100:0, 90:10, 80:20, 70:30, 60:40, and 0:100 in a kenwood blender (Mini-processor, Model A 90LD, Thom Emi Kenwood Small Appliances Ltd, Hampshire, UK) to obtain homogenous composite blends. The composite blends were packaged in plastics containers, labeled and stored in the refrigerator for further use.

CHEMICAL ANALYSIS

Moisture Determination

The moisture content of the samples was determ-ined using the air oven method of AOAC (2010).

Protein Determination

Crude protein content of the samples was determined using the automated micro-Kjeldahl method as described by AOAC (2005).

Fat Determination

The fat content was determined using the Soxhlet extraction method AOAC (2010).

Crude Fibre Determination

The crude fibre content of the samples was determined according to the procedure of AOAC (2010).

Ash Determination

The ash content was determined according to the procedure of AOAC (2010).

Carbohydrate Determination

Carbohydrate content was calculated by difference. The estimated percentages of crude protein, ash, fat, fibre and moisture was summed up and the value subtracted from 100%.

CHO = 100% - % (protein + fat + ash + fibre + moisture).

Mineral Determination

The mineral contents, namely: Na, K, Ca, Mg, Cu, Mn, Hg and Pb contents were determined by the method described by Pearson, (1976) using a PyeUnicam SP9 Atomic Absorption Spectro-photometer (AAS) connected to an SP9 computer (PyeUnicam Ltd, York Street, Britain). Total phosphorus was determined by the spectro-photometric molybdovanadate Pearson, (1976).

Functional Properties

Water Absorption Capacity (WAC)

Approximately 2 g sample was dispersed in 20 ml of distilled water. The contents were mixed for 30s every 10 min using a glass rod and after mixing five times, centrifuged at 4000 g for 20 min. The supernatant was carefully decanted and then the contents of the tube were allowed to drain at a 45° angle for 10 min and then weighed. The water absorption capacity was expressed as percentage increase of the sample weight AACC (1995).

Oil Absorption Capacity (OAC)

Oil absorption capacity of the flour samples was determined by the centrifugal method with slight modifications. One gram of sample was mixed with 10 ml of pure canola oil for 60 s, the mixture was allowed to stand for 10 min at room temperature, centrifuged at 4000 g for 30 min and the oil that separated was carefully decanted and the tubes were allowed to drain at a 45° angle for 10 min and then weighed. Oil absorption was expressed as percentage increase of the sample weight Beuchat, (1977).

Bulk Density

The bulk density was determined according to the method described by Udoro et al. Udoro and Kehinde, (2014). A 20 g sample was put into 50 ml measuring cylinder. The cylinder was gently tapped on the bench top 10 times from a height of 5 cm. The bulk density was calculated as weight per unit volume of sample.

Calculation: Bulk Density (BD) g/ml = *Weight of sample/Volume of sample after tapping*

Swelling Properties

The method used was as described by Okaka and Potter Okaka, (1977). About 25 g of flour was measured into a 100 ml measuring cylinder. The measuring cylinder was then filled with water to 100 ml bench mark. The mixture was shaken several times and allowed to settle. The volume of the flour was recorded after 15 minutes. The percentage swelling in the volume was determined by the difference in volume divided by the initial volume. Thus % swelling property = (C – D)/A

Where; A = Initial volume (equivalent volume of the 25 g flour sample); B = Volume before swelling; C = Volume after swelling

Foam Capacity (FC)

The procedure of Narayana and Narsinga Rao (1982) was used. Two grams of flour sample and 50 ml distilled water were mixed in a Braun blender at room temperature. The suspension was mixed and shaken for 5 minutes at 1600 rpm. The content along with the foam was poured into a 100 ml graduated measuring cylinder. The total volume was recorded after 30 seconds. Then the content was allowed to stand at room temperature for 30 minutes and the volume of foam only was recorded.

Foaming Capacity (FC) = (Vol. of foam AW − Vol. of foam BW)/ Vol. of foam AW x 100

Where; AW = After Whipping; BW = Before Whipping; FS: The volume of foam only (Total volume – liquid volume) after the 30 min standing is taken as foam stability.

RESULTS AND DISCUSSION

Results

Table1. *Proximate composition of maize and cooking banana composite flour blend (%)*

Sample	Protein	Fat	Ash	Fibre	Moisture	Carbohydrate
A	4.20^{a}±0.01	6.20^{a}±0.05	0.82^{f}±0.26	2.23^{f}±0.26	8.20^{f}±0.12	78.29^{d}±0.07
B	3.50^{b}±0.27	4.10^{b}±0.21	1.02^{e}±0.59	2.26^{e}±0.86	9.05^{e}±0.02	80.07^{a}±0.21
C	3.30^{c}±0.16	4.00^{c}±0.09	1.30^{d}±0.86	2.56^{d}±0.28	10.20^{d}±0.50	78.64^{b}±0.11
D	3.00^{d}±0.38	3.30^{d}±0.92	2.00^{c}±0.06	2.80^{c}±0.81	10.56^{c}±0.26	78.34^{c}±0.33
E	2.64^{e}±0.86	2.98^{e}±0.09	2.50^{b}±0.01	3.01^{b}±0.01	11.00^{b}±0.09	77.87^{e}±0.16
F	2.20^{f}±0.38	2.10^{f}±0.59	4.21^{a}±0.12	4.21^{a}±0.16	13.10^{a}±0.11	74.05^{f}±0.86

Values are mean ±standard derivation of 3 replication. Mean with different superscript along the same column are significantly different (P<0.05)

A = 100% Yellow Maize Flour, B= 90:10 Yellow maize and cooking banana flour, C= 80:20 Yellow maize and cooking banana, D= 70::30 Yellow maize and cooking banana, E=60:40 Yellow maize and cooking banana and F 100% cooking banana

Table2. *Mineral composition of maize and cooking banana composite flour blend (mg/100g)*

Sample	Fe	Ca	P	Zn	Mg	Na	K
A	4.02^{f}±0.45	0.86^{f}±0.65	39.14^{f}±0.30	1.38^{e}±0.79	163.15^{a}±0.69	10.20^{f}±0.01	67.48^{f}±0.04
B	4.30^{e}±0.01	0.86^{e}±0.65	50.00^{e}±0.24	1.38^{e}±0.03	154.00^{b}±0.76	12.60^{e}±0.50	70.15^{e}±0.21
C	4.56^{d}±0.02	17.30^{d}±0.34	53.20^{d}±0.81	1.42^{d}±0.01	140.20^{c}±0.42	14.30^{d}±0.11	76.26^{d}±0.07
D	5.10^{c}±0.72	20.50^{c}±0.01	60.70^{c}±0.68	1.56^{c}±0.47	135.00^{d}±0.13	16.10^{c}±0.24	89.44^{c}±0.81
E	8.60^{b}±0.50	25.00^{b}±0.01	65.80^{b}±0.42	1.70^{b}±0.65	131.47^{e}±0.50	16.59^{b}±0.01	117.33^{b}±0.81
F	12.20^{a}±0.42	130.40^{a}±0.65	90.68^{a}±0.50	2.06^{a}±0.81	120.53^{f}±0.01	24.70^{a}±0.42	130.43^{a}±0.02

Values are mean ±standard derivation of 3 replications. Mean with different superscript along the same column are significantly different (P<0.05)

A = 100% Yellow Maize Flour, B= 90:10 Yellow maize and cooking banana flour, C= 80:20 Yellow maize and cooking banana, D= 70::30 Yellow maize and cooking banana, E=60:40 Yellow maize and cooking banana and F 100% cooking banana.

Table3. *Functional properties of maize and cooking banana composite flour blend*

Sample	Bulk density (g/ml)	WAC (g/g)	OAC (g/g)	Foaming capacity (%)	Swelling Capacity (v/v)
A	0.63^{f}±0.42	175.42^{a}±0.33	110.24^{f}±0.08	2.30^{f}±0.33	5.00^{a}±0.61
B	0.65^{e}±0.08	170.50^{b}±0.61	113.10^{e}±0.75	2.33^{e}±0.23	4.51^{b}±0.6
C	0.68^{d}±0.33	168.70^{c}±0.42	118.30^{d}±0.02	2.40^{d}±0.75	4.30^{c}±0.08
D	0.70^{c}±0.61	163.50^{d}±0.23	121.08^{c}±0.42	2.42^{c}±0.61	3.86^{d}±0.33
E	0.71^{b}±0.75	151.10^{e}±0.02	123.01^{b}±0.47	2.48^{b}±0.04	3.60^{e}±0.42
F	0.78^{a}±0.02	137.67^{f}±0.75	130.66^{a}±0.33	2.68^{a}±0.08	3.08^{f}±0.75

Values are mean ±standard derivation of 3 replication. Mean with different superscript along the same column are significantly different (P<0.05)

A = 100% Yellow Maize Flour, B= 90:10 Yellow maize and cooking banana flour, C= 80:20 Yellow maize and cooking banana, D= 70::30 Yellow maize and cooking banana, E=60:40 Yellow maize and cooking banana and F 100% cooking banana.

Discussion

Proximate Composition

The results of the proximate composition of yellow maize and cooking banana composite flour blends are presented in Table 1. Moisture contents of the flour samples ranged from 8.26 to 13.10% with sample A (100% of maize flour) having the lowest moisture while sample F (100% of cooking banana flour) had the highest. The moisture content of the flour blends increased with increase in cooking banana addition. Moisture content is an index of water activity of many foods. These values were higher than moisture content of high-quality cassava flour samples which ranged from 4.15 to 11.90% Iwemo et al,(2017). The variation in moisture could be due to the processing method applied. This result is also an indication that the flour samples will keep well if properly stored under good conditions Kent, (1984). The moisture content of flour determines its storage stability which imply that the lower the flour moisture, the higher the storage stability. The ash content of the flour samples ranged from 0.82 to 4.21% with sample A 100% of maize flour having the lowest ash content value while sample F 100% of cooking banana had the highest. The ash content of the samples increased with increasing level of substitution of sample F in the blends. Ash content is a reflection of the mineral matter in a food sample. Fibre content of the blends ranged from 2.23 to 4.34%. Sample F had the highest fibre content (4.34%), followed by sample E (3.01), sample D (2.80) and sample C with 2.56%, while 100% maize flour had the least fibre content of 2.23%. There was an increased in the fibre content with increase in substitution with cooking banana. Fibre in food helps in burning of fat and busting of the immune system. It could also provide bulk in the diet, enhance gastrointestinal function, prevent constipation and may reduce the incidence of metabolic diseases like maturity-onset diabetes mellitus and hypercholesterolemia Farinde, (1984). Results obtained for fat showed that fat content ranged from 2.10 to 6.20% for the flour blends. Protein content of the flour blends ranged from 2.20 to 4.20% with 100% cooking banana flour having the lowest protein content values as was expected. The high protein content of maize flours is an indication that maize is a better source of protein compared to cooking banana. It is also evident from the result, that increasing level of maize flour increased protein content of maize-cooking banana flour composites. It has long been established that the bread-making performance of flours depends on the quantity and quality of their proteins content. On the other hand, sample B which is 90:10 maize-cooking banana flour blend recorded highest carbohydrate scores compared to other samples. The result recorded high carbohydrate contents for all the samples. This is an indication that both maize and cooking banana are good sources of carbohydrate.

Mineral

The iron content of the samples ranged from 4.02 to 12.20 mg/100g. Sample A had the lowest iron content while sample F contained the highest iron content. There is significant increase in iron with increase in substitution level of cooking banana. Iron is involved in strengthening the immune system. Iron is the functional component of haemoglobin and other key compounds used in respiration, immune function and cognitive development. The magnesium content of the samples ranged from 62.55 to 112.01 mg/100g. Sample A had the highest magnesium content of 163.15mg/100g while sample F contained the lowest mean value of 120.53mg/100g. There is decrease in the magnesium level with increase in the substitution level with cooking banana. Magnesium provides strength to the bone, aids enzymic action and help in heart functions. The zinc content of the samples ranged from 1.38 to 2.06mg/100g. Sample F had the highest mean value while sample A had the lowest value; however, all composite samples were significantly ($P<0.05$) different from each other. There was an increase in the zinc level with an increase in the substitution level with cooking banana. Zinc helps with hormone production, growth and repairment; improves immunity and facilitates digestion. Zinc also has a big impact on hormonal balance, so for this reason, zinc deficiency can result to an increased risk for infertility or diabetes Ndubuisi, (2009). Zinc has been recommended for the treatment of diarrhea by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF). Zinc is an effective therapy for diarrhea and will decrease diarrhea morbidity and mortality Christa, (2010). The result revealed that the calcium content of the samples ranged from 0.86 to 130.40mg/100g with sample F having the highest calcium content while sample A had the least value. The result showed an increase in calcium level with increase in the substitution level of cooking banana. Calcium had been reported to play a major role in muscle contraction, building strong bones and teeth, blood clotting, nerve impulse, transmission, regulating heart beat and fluid balance within cells Usman *et al.*, 2015). It has also been identified to play major role in managing blood pressure, and preventing breast cancer The phosphorus content of the samples ranged from 39.14 to90.68mg/100g. There was significant different ($P<0.05$) among all the samples. There was increase in the mean values with substitution of cooking banana thus; sample F had the highest mean value (90.68mg/100g) while sample A was lowest with the mean value of 39.14mg/100g. Phosphorus enhances quick release of energy in the body and may combine with calcium for bone and teeth development Ndubisi, (2009). The potassium content of the samples ranged from 67.48 to 130.43mg/100g. Sample F had the highest potassium level while sample F had the least potassium level. There is increase in the potassium level with increase in the substitution level with cooking banana. Potassium has been reported to play vital role in maintaining fluid balance and proper functioning of the essential organs such as the brain, nerves, heart and muscle Usman *et al.*, 2015).. Potassium aids nerve impulse transmission and it is a major cat ion of intracellular fluid. High potassium to low sodium ration in food may be imperative in diet formulations for patients with high blood pressure and oedema as well Ndubisi, (2009). The samples differed significantly (P≤ 0.05) from each other.

Functional Properties

The result of the functional properties of the composite flours are given in Table 3. Water absorption capacity ranged from 137.67- 175.42 g/g. Water absorption capacity (WAC) measures the ability of flour to absorb water and swell for improved consistency in food Okezie, (1988). The major chemical compositions that enhance the water absorption capacities of flours are proteins and carbohydrates since these constituents contain hydrophilic parts such as polar or charged side chains Niba et al(2001).There was increase in WAC with increase in the substitution level of cooking banana flour. Water absorption capacity is important in bulking and consistency of products as well as in baking applications Niba et al,(2001). Oil absorption capacity ranged from 110.24-130.66g/g. Oil absorption capacity increased with increase in level of substitution of cooking banana (110.24 – 130.66). Oil absorption capacity (OAC) is important because it acts as flavor retainer and increases the mouth feel of foods. The high oil absorption capacities of the flour blends suggest that they may be useful in food preparation that involve mixing like bakery products where oil is an important ingredient Bamigo, (2005).

Foam capacity ranged from 2.30-2.68%. Good foam capacity is a desirable attribute for flours intended for the production of variety of baked products such as bread, cakes, muffins, cookies etc. and also act as functional agents in other food formulations El-Adwy, (2001). It was noticed that as the level of substitution increases, the values for foam capacity kept increasing. Foams are used to improve texture, consistency and appearance of foods. The result of the bulk densities ranged from 0.63- 0.76% and increased considerably with increase in level of substitution. The relative high bulk density of the flour blends indicates that packaging would be economical as observed by Osundahunsi and Aworh (2002).

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