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Evaluation of Functional Properties of Flours from Millet, Cowpea and Unripe Plantain and Chemical Composition of Crackers from the Blends

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Abstract
Background: *Millet flour (MF), cowpea flour (CF) and unripe plantain flour (UPF) were produced and blended in ratios of 100:0:0, 80: 10:10, 70:20:10, 60:30:10 and 50: 40:10 and coded with MCP1, MCP2, MCP3, MCP4 and MCP5 to produce crackers. Millet, cowpea and unripe plantain flours were analyzed for functional properties and proximate composition while crackers made from the blends were analyzed for proximate composition, micronutrients composition and phytochemicals composition. Significant differences were observed in the functional properties of flours. Unripe plantain flour was significantly (p<0.05) higher in oil absorption capacity and swelling capacity than other samples and cowpea flour was significantly higher than other samples in water absorption capacity. In proximate composition millet flour had higher scores for moisture, fat, crude fibre and carbohydrate, while cowpea flour recorded higher scores for ash, and protein. Significant (p<0.05) differences existed in proximate composition of the crackers, sample MCP1 recorded the highest score for carbohydrate (76.70%) and least scores for ash (0.60%), fat (3.135), moisture (8.54%), crude fibre (3.69%) and protein (7.21%). In mineral content it was also observed that sample MCP1 recorded least in zinc (0.35mg/100g), magnesium (16.33mg/100g) and potassium (36.35mg/100g) the same trend was reported for vitamins beta carotene(5.42 ug/g), vitamin C (6.32 ug/g) and vitamin B1(1.40 ug/g). In all the assessed chemical properties sample MCP5 containing 50% millet, 40% cowpea and 10% unripe plantain was the best.*
Materials and Methods: *Functional properties (water absorption capacity) was determined using the method of Lin et al. (1974). Bulk density was determined according to the method documented by Onwuka, (2005), swelling capacity was determined according to the method described by Ukpabi and Ndimele (1990), oil absorption capacity was determined using the method of Lin et al. (1974)Proximate composition was carried out according to the method of AOAC 2010,mineral composition according to the method of AOAC, 2010. Beta carotene according to the method of Pearson, 1976. Vitamin C content was determined according to the method of Olokodona, (2005). Thiamine content was determined according to the method of Onwuka, (2018). The flavonoid content was determined using the method of Harborne (1980). The total phenolic content (mg/g) were determined using the Folin-Ciocalteu method (Bobinait et al, 2012), Alkaloid content was determined by the alkaline precipitation gravimetric method described by Harbourne (1980).*
Results : *Significant differences existed between samples in most of the parameters assessed.*
Conclusion: Blending of millet, cowpea and unripe plantain helped in production of suitable crackers for health conscious individuals considering the chemical composition of the crackers.
Key words: *Crackers; Proximate; Mineral; Phytochemicals; Vitamins; Millet*

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I. Introduction

The snack food industry is growing globally with rapid introduction of new products formulated with the intent of meeting specific health or organoleptic needs of consumers. These products are increasingly becoming available every year especially in developed countries. However, they are also exported to developing countries, where snacks are relied upon to meet the physiological needs of the populace particularly children[1]. Choosing healthy snack foods is just as important at snack time as it is at meal time, therefore it is possible to improve the nutritional quality of cereal proteins by combination with leguminous plant protein sources[2] such as pigeon pea, cowpea and soybeans amongst others.

Biscuit is a small thin crispy cake made from unleavened dough that is transformed into a light porous, readily digestible and appetizing product through the application of heat. The principal ingredients are flour, fat, sugar and water, while other optional ingredients include milk, salt, flavouring agent, aerating agent and other food additives[3]. Biscuits are a rich source of fat, protein, minerals and carbohydrate, hence provide energy[3]. They can be served with soft drinks or tea, and taken between meals like any other snack. Crackers are biscuits having typical flaky inner layers. Crackers contain little sugar, moderate levels of fat and relatively low levels of salt[4]. Consequently, crackers can be used as a good substitute for sweeter snacks for health conscious consumers. Crackers biscuit can be considered as one of the most desirable snacks due to their good eating quality and superior nutritional properties. A total dependence on the use of wheat flour is a major constraint in biscuit production therefore it is necessary to delve into the production of biscuit (crackers) from other flours other than wheat flour.

Millet (*Pennissetum glaucum* L.), is a staple food in many African countries. It is used for various foods and traditional drinks. Many millet varieties have higher protein, energy, mineral and vitamin content than other cereals[5]. Millet (*Pennissetum glaucum* L.) is rich in methionine and poor in lysine and cysteine, which are essential amino acids[6]. Many wheat-based products, particularly those from pastry and bakery are increasingly supplemented with millet and sorghum to reduce gluten levels. The use of millet in the bakery and pastry industry does not only improve the nutritional value of the products but creates added value[7]. Grain products are high in energy, but poor in nutritional value[8,9]. Like all cereals, the content of some essential amino acids such as lysine is insufficient to meet the nutritional requirements recommended by the[10].

The introduction of legumes into the production of biscuits is a way to improve the nutritional status of people. Legumes are characterized by high levels of protein (18-34 %)[11] compared to cereals. They are rich in essential amino acids such as lysine, tryptophan, and methionine[12],[13]. In addition, legumes have the advantage of being traditionally produced and consumed in many developing countries where nutritional deficiencies are a public health problem. According to the[14], over 80 % of cowpea production comes from sub-Saharan Africa. Cowpea (*Vigna spp*), an annual legume, is also commonly referred to as southern pea, black eye pea and crowder pea. Cowpea originated in Africa and is widely grown in Africa, Latin America, South East Asia and in the Southern United States. It is mainly used as a grain crop, for animal fodder, or as a vegetable. Nutrients provided by cowpea make it extremely valuable where many people cannot afford proteins from animal sources such as meat and fish. Cowpea is well adapted to the stressful growing condition of the tropics and has excellent nutritional qualities.

Apama (*Vigna sinensis*) is a traditional cowpea variety grown in African countries such as Nigeria and Niger and consumed as dried seeds. Others are *olaludi* and *akidi*, the major characteristics of these are their small seed sizes and shiny seed coats. *Apama* is used to replace pigeon pea in some traditional dishes like yam porridge, *ayaraya* and *achicha*. *Apama* is planted April/May and harvested in June-July[15].

Nigeria is one of the largest Plantain (*Musa paradisiaca*) producing countries in the world more than 2.5 million metric tons of plantains are produced in Nigeria annually [16], but about 40–60% post-harvest losses had been reported which is attributed to lack of storage facilities and inadequate technologies for food processing. In Nigeria and many African countries, plantain (*Musa paradisiaca*) is used as an inexpensive source of calories[17]. It is one of the most important sources of food energy in West and Central Africa, where about 70 million people derive more than 25% of their carbohydrates from plantains[18]. When processed into flour it is used traditionally for preparation of gruel which is made by mixing the flour with appropriate quantities of boiling water to form a thick paste. It is also consumed as snacks in form of chips, “dodo ikire”, among others. It is however, gradually finding applications in weaning food formulation and composite flour preparations [19]. [20] has shown that plantain flour has a good potential for use as a functional agent in bakery products because it has high water absorption capacity (WAC). It has also recorded success when used in addition to the conventional wheat flour. Furthermore[21], reported that feeding mainly on plantain cannot meet up with the daily protein requirement, therefore protein supplementation is essential. Millet, cowpea and unripe plantain based biscuit could be made by the addition of unripe plantain and cowpea flour to millet flour with ingredients such as fat, baking powder, egg, milk, among others.

The high rate of snack consumption in developing countries and the world over is a major concern that draws attention to the nutritional quality of snacks. Snacks such as biscuits are usually carbohydrate-based this leads to the problem of protein-energy malnutrition. On the other hand, aged people tend to avoid sugary biscuits and rely more on functional foods that have both nutritional and health benefits, hence, the addition of unripe plantain and cowpea to the millet flour becomes necessary. The objective of this research was to produce and evaluate the chemical quality of crackers biscuits, made from millet, cowpea and unripe plantain flour blends.

II. Materials And Methods

Millet grains, cowpea seeds and unripe plantain were purchased from *Ogige* market in Nsukka Enugu State, Nigeria as well as additives such as sugar, baking fat, baking powder, milk, flavour, among others.

Preparation of samples

Millet (*Pennissetum glaucum)* flour

The millet flour was produced using the modified method of[22]. The millet grains were cleaned to remove extraneous materials, winnowed and sieved with a mesh to remove stones. Lime juice was prepared at pH of 3.7 and used to soak the millet for 92 hours in order to improve the colour and reduce the anti-nutrients in them. After soaking, the grains were washed thoroughly and dried in an oven at 50°C for 4 hours. It was milled using attrition mill and sieved with muslin cloth of 2mm pore size. The flow diagram for the production of millet flour is shown in Figure 1.

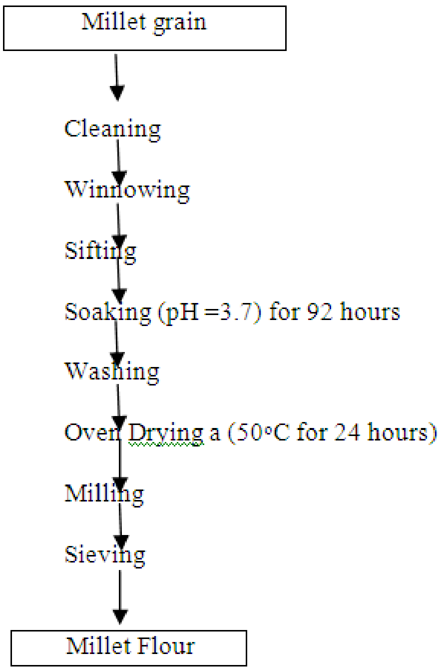

Fig. 1: Processing of millet flour[22]

Processing of cowpea (*Vigna sinensis*) flour

Cowpea was processed into flour according to the method described by[23] .The cowpea seeds were cleaned to remove extraneous materials, washed to remove sand and solar dried for 10hrs. The cowpea seeds were roasted for 130 °C for 30 minutes using a grain roaster. Cracked, dehulled and milled in an attrition mill before sieving using a muslin cloth of 2mm pore size to obtain the cowpea flour. The process is as shown in Figure 2.

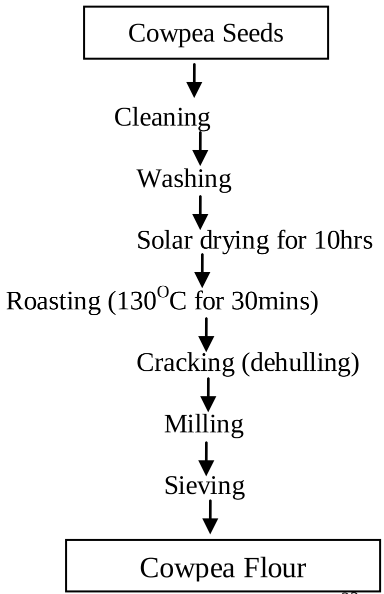

Fig. 2 : Processing of cowpea flour[23]

Processing of unripe plantain (*Musa paradisiaca*) flour

Unripe plantain was processed using the method described by[23], as shown in Figure 3. The unripe plantain was washed along with the skin to reduce contamination, peeled manually, sliced to obtain a uniform size for easy drying, oven dried at 60°C for 12 hours and milled using attrition mill. The flour was sieved using muslin clothe of 2 mm pore size to obtain unripe plantain flour.

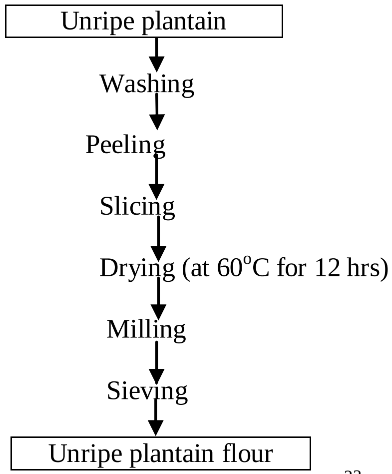

Fig. 3: Processing of unripe plantain flour[23]

Formulation of Flour Blends

Millet flour (MF), cowpea flour (CF) and unripe plantain flour (UPF) were produced and blended in ratios of 100:0:0, 80: 10:10, 70:20:10, 60:30:10 and 50: 40:10 and coded with MCP1, MCP2, MCP3, MCP4 and MCP5 respectively as shown in Table 1.

Table no 1: Composite flour blends from millet, cowpea and unripe plantain flours (%)

Sample	Millet Flour	Cowpea Flour	Unripe Plantain Flour
MCP1	100	0	0
MCP2	80	10	10
MCP3	70	20	10
MCP4	60	30	10
MPC5	50	40	10

Key: MCP1= 100% millet, 0% cowpea and 0% unripe plantain,
MCP2= 80% millet, 10% cowpea and 10% unripe plantain,
MCP3= 70% millet, 20% cowpea and 10% unripe plantain,
MCP4= 60% millet, 30% cowpea and 10% unripe plantain,
MCP5= 50% millet, 40% cowpea and 10% unripe plantain.

Production of crackers

Crackers were prepared using the method described by[24] with slight modifications. The flour (500g), sugar (100g), baking powder (2.5g), vanilla (5g) and salt (5g) were mixed together manually until well combined. Baking fat (150g) was rubbed into the mixture. Water (125ml) was gradually added using continuous mixing until good textured, slightly firm dough was obtained. The dough was kneaded on a clean flat surface for five minutes. Manually rolled into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were transferred into fat greased pans and baked in an oven at 180ºC for 20 minutes, cooled and packaged for further analysis. The flow diagram for the preparation of crackers is shown in Figure 4.

Weighing of Ingredients
↓
Mixing of dry ingredients
↓
Addition of water
↓
Dough mixing
↓
Dough kneading
↓
Dough rolling
↓
Dough cutting
↓
Loading (into greased trays)
↓
Preheating of oven (200℃ for 10 minutes)
↓
Baking (180℃ for 20mins)
↓
Cooling of biscuit (10-20mins)
↓
Packaging

Fig. 4: Production of crackers[24]

Evaluation of Functional Properties of flours

Determination of water absorption capacity (WAC)

This was determined using the method of[25]. One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 2000 rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain. The weight of water absorbed was determined by difference. The water absorption capacity was calculated as:

$$\text{WAC\%} = \frac{\text{volume of water used} - \text{volume of free water}}{\text{weight of sample used}} \times \frac{100}{1}$$

Determination of bulk density (BD)

Bulk density was determined according to the method documented by[26]. A graduated measuring cylinder of 10 ml capacity was weighed and gently filled the sample. The cylinder was tapped continuously at the bottom until a constant volume is obtained. The bulk density was calculated as:

$$\text{Bulk density } (g/m^3) = \frac{\text{Weight of sample (g)}}{\text{Volume of sample after tapping (ml)}}$$

Determination of swelling capacity

The method described by[27] was used. Ten grams of the sample was measured into a 300ml measuring cylinder. Then 150ml of distilled water was added to the sample and allowed to stand for four hours. The final volume after swelling was recorded. The percentage swelling was calculated as;

$$\text{Swelling capacity\%} = \frac{\text{final} - \text{initial volume}}{\text{Initial volume}} \times \frac{100}{1}$$

Determination of oil absorption capacity

Oil absorption capacity was determined using the method of[25]. One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of winterized oil and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 2000 rpm for 30 minutes. The excess oil (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain. The weight of oil absorbed was determined by difference. The oil absorption capacity was calculated as:

$$\text{OAC} = \frac{W_3 - W_2 - W_1 \times 100}{\text{Vol } 1}$$

Where;

W_3 = weight of the sample and centrifuge tube after discarding the water that was not absorbed.

W_2 = weight of centrifuge tube

W_1= weight of sample
vol = volume of oil used (10ml)
Chemical Analysis
Proximate Analysis
Proximate composition of samples was determined according to the standard methods of Association of Official Analytical Chemists[28].

Determination of moisture content
Stainless steel oven dishes were cleaned and dried in the oven at 100ºC for 1 hour to achieve a constant weight. They were cooled in a desiccator and then weighed. Two grams of sample was placed in each dish and dried in the oven at 100ºC until constant weight was achieved. The dishes together with the samples were cooled in a desiccator and weighed.

$$\% \text{ moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where
W_1 = weight of dish
W_2 = weight of dish + sample before drying
W_3 = weight of dish + sample after drying

Determination of protein content
a. Digestion of the sample
The samples (1 g) were weighed into Kjeldahl digestion flask, and addition of 1 tablet of Kjeldahl catalyst followed. Twenty-five milliliters (15 ml) of concentrated tetraoxosulphate (IV) acid (H_2SO_4) was be added with few boiling chips. The flask with its content was heated in the fume chamber until a clear solution obtained. The solution was cooled to room temperature after which it was transferred into a 250 ml volumetric flask and made up to the level with distilled water.

b. Distillation
The distillation unit was cleaned and the apparatus set up. A 100 ml conical flask (receiving flask) containing 10 ml of 2 % boric acid was placed under the condenser with the addition to 2 drops of methyl red indicator. A digest of 10 ml was pipette into the apparatus through the small funnel, washed down with distilled water followed by the addition of 10 ml of 40 % NaOH (sodium hydroxide) solution. The digestion flask was heated until 100 ml of distillate (ammonium sulphate) was collected in the receiving flask.
The solution in the receiving flask was titrated with about 0.01M HCl to get a pink colour. The same procedure would be carried out on the blank.

$$\%N = \frac{T \times M \times 0.014 \times DF \times 100}{g}$$

Where: g = weight of sample
T = titre value
DF = dilution factor
% crude protein = N x 6.25 (conversion factor)

Determination of fat content
A 500ml capacity round bottom flask was filled with 300ml petroleum ether and fixed to the soxhlet extractor. Two grams of sample was placed in a labeled thimble. The extractor thimble was sealed with cotton wool. Heat was applied to reflux the apparatus for six hours. The thimble was removed with care. The petroleum ether was recovered for reuse. When the flask was free of ether it was removed and dried at 105ºC for 1 hour in an oven. The flask was cooled in a dessicator and weighed.
Calculation:

$$\% \text{ fat} = \frac{\text{weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of crude fibre content
Two grams of the sample was defatted using petroleum ether. It was boiled under reflux for 30 minutes with 200ml of 1.25% H_2SO_4.The solution was filtered through a muslin cloth on a funnel after which it was washed with boiling water until the washing was no longer acidic. The residue was transferred into a beaker and boiled for 30 minutes with 200 ml of a solution of 1.25% of carbonate free NaOH per 100ml.The final residue

was then filtered through a thin pad of washed and ignited asbestos in a Gooch crucible. It was dried in an oven and weighed, after which it was incinerated, cooled and weighed again. The percentage crude fibre was calculated as:

$$\% \text{ crude fibre} = \frac{\text{Loss in weight after incineration} \times 100}{\text{Weight of sample}}$$

Determination of ash content

Two grams of sample was placed in silica dish which had been ignited, cooled and weighed. The dish and sample were ignited first gently and then at 550ºC in a muffle furnace for 3 hours, until a white or grey ash was obtained. The dish and content were cooled in a dessicator and weighed.

$$\% \text{ Ash} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times \frac{100}{1}$$

Where;

W_1 = weight of dish

W_2 = weight of dish + sample before ashing

W_3 = weight of dish + sample after ashing

Determination of Carbohydrate content

Carbohydrate content was determined by difference as follows:

% Carbohydrates = 100 – (% moisture + % fat + % ash + % protein + % crude fibre)

Determination of calorific content

The values obtained for protein, fat and carbohydrate were used to calculate the calorific content of the samples using Atwater factor as described by[28].

Calorific value (Kcal/100g) = P x 4.0 +F x 9.0+C x 3.75

Where P,F. and C are the % content of protein, fat and carbohydrate in the sample respectively.

Determination of Selected Micronutrient

Determination of minerals (calcium, iron, zinc and potassium using atomic absorption spectrophotometer (AAS).

Sample Preparation

Calcium, Iron, Zinc and Potassium were determined using AAS as described by[28]. One gram (1 g) of the sample was first digested with 30 ml of aqua regia which is a mixture of concentrated HNO_3 and HCL in the ratio of 1: 3. The digested sample was filtered and made up to 50 ml with deionized water. The aliquots of the digested filtrate were used for AAS using filters that match the different elements.

Determination using AAS

Calibration curves were prepared for each element using standard solution. Each mineral to be determined has a hollow cathode lamp complementary to it as well as a particular wavelength. The lamp directs the wavelength to the sample and the concentration of the mineral in the sample is determined with its corresponding value.

Vitamin Determination

Determination of beta carotene

Beta-carotene was determined using the method[29]. The sample 1 g was extracted by mixing with 20 ml of petroleum ether. The extract was evaporated to dryness and the residue dissolved with 0.2 ml chloroform-acetic anhydride mixture. 2 ml of trichloro acetic acid (TCA) was also added to the extract mixed thoroughly and the absorbance read at 620 nm within 15 seconds. With the absorbance value, beta-carotene was calculated thus:

Calculation

$$\text{concentration (mg/)} = \frac{\text{Abs} \times \text{Volume of cuvette} \times \text{Df)}}{\text{E}}$$

Where:

A= absorbance

Df= Dilution factor

E= Extinction coefficient.

Determination of vitamin C

Vitamin C content was determined according to the method of[30]. Five gram of the sample was weighed into a 100 ml volumetric flask, 2 ml of 20 % meta-phosphoric acid was added as stabilizing agent and the solution was diluted to volume with distilled water. Ten (10) ml of the solution was pippeted into a small flask and 2.5 ml of acetone added. The solution was titrated with indophenols solution until a faint pink colour persisted for 15 seconds. The vitamin C content was calculated as mg/100 ml.

Determination of vitamin B1 (Thiamin)

Thiamine content was determined according to the method of[31]. Thiamine complex is first extracted with dilute HCl and the resultant solution was treated with phosphatase enzyme to liberate free thiamin. After this, the absorbance was taken at 435 nm wavelength.

Calculations

$$\text{Thiamin} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \frac{\text{conc of standrad}}{\text{weight used}}$$

Determination of Phytochemicals

Determination of flavonoids

The flavonoid content was determined using the method of[32]. Five grams of the sample was boiled in 50ml of 2M HCl solution for 30 minutes under reflux. It was allowed to cool and filtered through whatman No 42 filter paper. The extract was equal volume of ethyl acetate. The flavonoid precipitated was recovered by filtration using filter paper . The weight difference was taken as the weight of the flavonoid in the sample.

Determination of phenol content

The total phenolic content (mg/g) were determined using the Folin-Ciocalteu method[33], calculated from a gallic acid caliberation curve, and expressed as mg/g gallic acid equivalent (GAE) per gram of absolutely dry weight (DW) (mg GAE/g DW).

Determination of alkaloid content

Alkaloid content was determined by the alkaline precipitation gravimetric method described by[32]. Five grams of sample (w) was weighed into 50ml acetic acid solution in ethanol in a 250ml beaker. The filtrate was evaporated to one quarter of its original volume by evaporating using a steam bath. Alkaloids in the extract were precipitated by drop-wise addition of ammonium hydroxide (NH_4OH) until full turbidity was obtained. The alkaloid precipitate was recovered by filtration using a weighed filter paper (W_1) and washed with 1% ammonium solution (NH_4O4), dried in the oven at 60℃ for 30 minutes and reweighed (W_2). By weight difference, the weight of alkaloid was determined and expressed as percentage of the sample analyzed using the formula:

$$\%\text{Alkaloids} = \frac{W_2 - W_1 \times 100}{W}$$

Where:

w= weight of sample

w_1=weight of empty filter paper

w_2= weight of paper plus precipitate

Experimental Design and Data Analysis

The experiment was laid out on a Completely Randomized Design (CRD). Data were subjected to Analysis of Variance (ANOVA) using Statistical Product for Service Solutions (SPSS) version 25.0. Duncan's new multiple range test (DNMRT) was used to compare the treatment means. Statistical significance was accepted at $p \leq 0.05$[34].

III. Results

Table no 2: Selected functional properties of raw materials (millet, cowpea and unripe plantain flours)

Sample	Oil absorption capacity(g/100g)	Bulk density (g/ml)	Water absorption capacity (g/100g	Swelling capacity (g/100g)
MF	13.01a±0.20	0.63a±0.02	10.43b±0.33	33.40b±0.14
CF	13.23a±0.13	0.74a±0.01	14.52c±1.37	25.00a±0.00
UPF	17.55b±0.28	0.68a±0.15	8.01a±4.00	50.00c±0.00

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly (p<0.05) different.

Key: MF = millet flour, CF = Cowpea flour, UPF = Unripe plantain flour.

Table no 3: Proximate composition of raw materials (millet, cowpea, and unripe plantain flours)

Sample	Moisture (%)	Fats (%)	Ash (%)	Crude Fibre(%)	Protein (%)	Carbohydrates (%)
MF	3.55^{a} ±0.66	2.70^{b}±0.14	0.60^{a}±0.14	3.65^{c} ±0.21	8.75^{a} ±0.71	80.71^{b} ±0.53
CF	5.00^{b}±0.035	1.85^{a}±0.49	3.90^{c}±0.57	3.17^{b} ±0.28	24.06^{b} ±0.00	62.05^{a} ±2.00
UPF	5.98^{b}±0.00	1.20^{a}±0.00	1.70^{b}±0.00	3.10^{a} ±0.01	4.38^{a} ±3.09	84.30^{b} ±0.01

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly (p<0.05) different.
Key: MF = millet flour, CF = Cowpea flour, UPF = Unripe plantain flour.

Table no 4: Proximate composition and energy value of crackers made from millet, cowpea and unripe plantain flour blends (%).

Sample	Ash	Fats	Moisture	Crude Fibre	Protein	Carbohydrates	Calorific content (Kcal)
MCP1	0.61a±0.01	3.13a±0.03	8.54a±0.01	3.69a±0.00	7.21a±0.01	76.70e±0.11	341.34±0.03
MCP2	0.91b±0.14	4.66b±0.01	9.58b±0.21	3.99b±0.00	10.63b±0.00	69.65d±0.17	345.61±0.02
MCP3	1.21c±0.03	4.67c±0.14	9.29c±0.07	3.98b±0.14	12.38c±0.01	68.47c±0.02	348.34±0.01
MCP4	1.39d±0.00	4.69b±0.00	11.03d±0.01	4.19c±0.01	12.85d±0.00	65.88b±0.01	340.63±0.01
MCP5	1.91e±0.01	4.75d±0.01	11.09e±0.14	4.20c±0.00	16.86e±0.00	61.33a±0.14	340.07±0.03

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly (p<0.05) different.
Key: MCP1= 100% millet, 0% cowpea and 0% unripe plantain,
MCP2= 80% millet, 10% cowpea and 10% unripe plantain,
MCP3= 70% millet, 20% cowpea and 10% unripe plantain,
MCP4= 60% millet, 30% cowpea and 10% unripe plantain,
MCP5= 50% millet, 40% cowpea and 10% unripe plantain.

Table no 5: Mineral composition of crackers made from millet, cowpea and unripe plantain flour blends (mg/100g)

Sample	Zinc	Magnesium	Potassium	Calcium
MCP1	0.35 a ±0.01	16.33 a ±0.00	36.35 a ±0.00	63.33 a ±0.00
MCP2	0.39 b ±0.01	16.51 b ±0.00	46.80 b ±0.01	63.33 a ±0.01
MCP3	0.65 c ±0.00	17.20 c ±0.01	51.06 c ±0.01	63.33 a ±0.01
MCP4	1.13e±0.00	18.35 d ±0.01	68.07 d ±0.01	66.67 b ±0.01
MCP5	6.83 d ±0.01	26.14 e ±0.00	73.48 e ±0.00	80.00 c ±0.00

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly (p<0.05) different.
Key: MCP1= 100% millet, 0% cowpea and 0% unripe plantain,
MCP2= 80% millet, 10% cowpea and 10% unripe plantain,
MCP3= 70% millet, 20% cowpea and 10% unripe plantain,
MCP4= 60% millet, 30% cowpea and 10% unripe plantain,
MCP5= 50% millet, 40% cowpea and 10% unripe plantain.

Table no 6: Vitamins composition of crackers made from millet, cowpea and unripe plantain flour blends.

Sample	Beta carotene (ɥg/g)	VitaminC (mg/100g)	VitaminB1 (mg/100g)
MCP1	5.42^{a}±0.06	6.32^{a}±0.02	1.40^{a}±0.14
MCP2	5.87^{b}±0.04	9.46^{b}±0.01	1.60^{ab}±0.14
MCP3	6.54^{c}±0.05	9.48^{b}±0.01	1.90^{bc}±0.14
MCP4	7.87^{d}±0.02	9.48^{b}±0.01	2.25^{cd}±0.21
MCP5	9.85^{e}±0.91	10.53^{c}±0.02	2.45^{d}±0.01

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly (p<0.05) different.
Key: MCP1= 100% millet, 0% cowpea and 0% unripe plantain,
MCP2= 80% millet, 10% cowpea and 10% unripe plantain,
MCP3= 70% millet, 20% cowpea and 10% unripe plantain,
MCP4= 60% millet, 30% cowpea and 10% unripe plantain,
MCP5= 50% millet, 40% cowpea and 10% unripe plantain.

Table no 7: Phytochemicals composition of crackers from blends of millet, cowpea, and unripe plantain flour

Sample	Flavonoids (mg/100g)	phenols (mg/100g)	Alkaloids (%)
MCP1	$0.11^{a}\pm0.00$	$1.06^{b}\pm0.02$	$1.08^{a}\pm 0.02$
MCP2	$0.08^{a}\pm0.02$	$0.98^{a}\pm0.01$	$1.21^{b}\pm0.01$
MCP3	$0.08^{a}\pm0.01$	$1.04^{b}\pm0.02$	$4.71^{c}\pm0.02$
MCP4	$0.08^{a}\pm0.00$	$1.36^{c}\pm0.01$	$5.99^{d}\pm0.01$
MCP5	$0.08^{a}\pm0.01$	$1.41^{d}\pm0.01$	$12.58^{e}\pm 0.02$

Values are means ±S.D of duplicate determinations. Means in the same column with different superscripts were significantly ($p<0.05$) different.

Key: MCP1= 100% millet, 0% cowpea and 0% unripe plantain,
MCP2= 80% millet, 10% cowpea and 10% unripe plantain,
MCP3= 70% millet, 20% cowpea and 10% unripe plantain,
MCP4= 60% millet, 30% cowpea and 10% unripe plantain,
MCP5= 50% millet, 40% cowpea and 10% unripe plantain.

IV. Discussion

Functional properties of flours of raw materials (millet, cowpea and unripe plantain)

Selected functional properties of the raw materials is shown in Table 2. Functional properties explain how food ingredients behave during the preparation and cooking, how they impact the finished food products in terms of appearance, texture, structure, and taste. Functional properties of foods and flours are influenced by the components of the food material, especially the carbohydrates, proteins, fats and oils, moisture, fibre, ash, and other ingredients or food additives added to the food or flour, as well as the structures of these components[35].

Oil absorption capacity (OAC) ranged from 13.01 to 17.55g/100g. The lowest value was observed in MF. There was no significant ($p>0.05$) difference between samples MF and CF in oil absorption capacity, while unripe plantain flour recorded the highest value (3.12g/100g) and differed significantly ($p<0.05$) from all the other flour samples. The ability of the flours to bind with oil makes them useful in food applications where optimal oil absorption is desired, making flours to have potential functional applications in foods such as production of pastries of which crackers is one of them. The oil absorption capacity also makes the flour suitable in facilitating enhancement in flavour and mouth feel when used in food preparation[36].

Bulk density of the flour samples ranged from 0.63 to 0.74g/ml. Cowpea flour had the highest value. There was no significant ($p>0.05$) differences among samples in bulk density. The lowest value (0.63g/ml) was observed in millet flour (MF). Bulk density is a measure of heaviness of a flour sample[37]. This implied that millet flour would require more packaging space since the lesser the bulk density, the more packaging space is required[38]. The low bulk density observed show that this flour can be used for food formulation with less fear of degradation.

Water absorption capacity (WAC) ranged from 8.01 to 14.52g/100g. The lowest value was observed in Unripe Plantain Flour. Significant ($p>0.05$) differences existed among all the samples in WAC. Water absorption capacity describes flour-water association ability under limited water supply[39]. These results suggest that Millet Flour (MF), Unripe Plantain Flour (UPF) and cowpea flour (CF) will find application in baked products such as crackers because they possess the ability to absorb reasonable quantities of water to form pliable dough.

Swelling capacity of the flour samples ranged from 25.00 to 50.00% with the highest value observed in unripe plantain flour. There were significant ($p<0.05$) difference between the three flour samples. The swelling capacity is the measure of the starch ability to absorb water and swell, and also reflects the extent of associative forces in the starch granules. Swelling capacity (index) is considered a quality measure in baked food products[40]. The swelling capacity of the flours is influenced by particle size and unit operations employed during processing among many other factors[36].

Proximate composition of raw materials (millet, cowpea and unripe plantain flours)

Proximate composition of flour obtained from processing millet, cowpea and unripe plantain are shown in Table 3.There were significant ($p<0.05$) differences in all the measured parameters. Moisture content of the flour samples ranged from 3.55 to 5.98 %. These values are below the minimum limit of moisture content for flour[41]. The values are therefore low enough for adequate shelf stability if packaged in moisture-proof containers.

Fat content of the flour samples were generally low, ranging from 1.2 to 2.7 %. Significant ($p<0.05$) differences were observed among the samples. The fat value was highest in millet flour (3.0 %), while 1.2 % was observed in unripe flour. The higher fat content of millet flour can be attributed to the fact that millet germ is rich in oil[42]. Most legumes such as cowpea contain less than 3 % fat[40].

Ash contents of the flour samples ranged from 0.60 to 3.90 %; which shows the presence of some minerals in the flour samples.

Crude fibre content of the flour samples ranged from 3.10 to 3.65 % with the highest value observed in the millet flour. This is appreciated in this study because of the enormous health benefits of fibre. Fibre aids in lowering blood cholesterol level and slows down the process of absorption of glucose, thereby helping in keeping blood glucose level in control. Fibre also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body[43].

Protein content of the flour samples ranged from 4.38 to 24.06 %. Significant ($p<0.05$) differences were observed among the samples. The highest protein value was observed in cowpea flour. The protein content of millet flour was 8.75 %. Millet grains are also known to contain appreciable quantity of protein of about 11 %[44], the disparity may be attributed to differences in geographical areas of cultivation of the millet grains. The lowest value of 4.38 % was observed in unripe plantain flour. The protein is required by the aged for body building. The protein content of cowpea reported in the present study was higher than 22.9 % reported by[45] for bambara groundnut.

There were significant ($p<0.05$) differences in the carbohydrate contents of the flour samples. Carbohydrate contents of millet flour (80.71%) compared favourably with 84.30 % observed for unripe plantain flour in the present research. According to[24] carbohydrate contents ranging from 75 to 80 % was reported for biscuit made from millet/pigeon pea flour blends.[46], reported that high carbohydrate is important as it provides the energy needed to do work.

Proximate composition of crackers made from millet, cowpea and unripe plantain flour blends.

Proximate composition of crackers is shown in Table 4.Ash contents ranged from 0.61 to 1.91%, the control sample (MCP1) containing 100 % millet had the least ash content in comparison with other samples blended with cowpea and unripe plantain, this is attributed to the fact that millet flour recorded the least ash content (Table 2). Ash content increased as cowpea incorporation increased. This clearly shows that cowpea added to the ash content of the crackers. Thus, sample containing the highest cowpea level (MCP5), recorded the highest ash content (1.91 %) which suggests that the snack will be a potential source of mineral elements.

Fat contents ranged from 3.13% to 4.75 % with the control (MCP1) having the lowest fat content. There were significant differences ($p < 0.05$) in the fat contents of the formulated crackers in spite of the fact that equal amount of fat (margarine) were measured for crackers production. The variation could be due to differences in the oil absorption capacities of the different flour blends, however higher values of 12.83% to 21.39% were obtained by[47] for fat as incorporation of pigeon pea flour increased in blends of acha and pigeon pea flour for production of crackers.

Moisture content ranged from 8.54 to 11.09 %. Significant ($p<0.05$) differences existed among all the samples in moisture content. The highest value was observed in sample (MCP5) which had 40 % cowpea flour. This could be as a result of the high water absorption capacity of cowpea flour, so that at higher level of incorporation (40%), the product would contain more moisture. This result compared well with the report of[48]. Crackers are generally low moisture foods. This moisture range will enhance shelf stability of the products.

Crude fibre content ranged from 3.69 to 4.20 % and significant ($p<0.05$) differences existed among samples. The level of crude fibre increased in the formulated crackers with increase in supplementation of cowpea flour, which suggests that cowpea flour contributed to the fibre contents of the crackers, cowpea being a fiber-rich legume. Similar values were obtained by[47] for fibre In development of value added nutritious crackers from blends of acha and blanched pigeon pea flours. However lower values of 0.0 to 0.1% were obtained by[24] for fibre in crackers with increased incorporation of pigeon pea flour to millet flour. These differences can be attributed to varietal differences and differences in geographical areas of cultivation.

Protein content ranged between 7.21 % (MCP1) to 16.86 % (MCP5). The control crackers sample formulated without cowpea and unripe plantain had the least protein content (7.21 %) and differed ($p<0.05$) significantly from the other samples. From the table 4, it was observed that there was an increase in the mean protein content in each sample as the proportion of cowpea increased Similar result of increased protein content from 5.0 % to 14.2 % was reported for biscuits from wheat–soybean flour[49], [50] also reported protein contents of 14.57 % and 19.80 % for cookies produced from unripe plantain and defatted sesame seed flours at ratios of 80:20 and 70:30 respectively. The addition of cowpea flour increased the protein content of the crackers. Foods that are rich in protein is very important in developing countries like Nigeria, to battle the prevalence of protein malnutrition. Proteins are needed for growth, repair and maintenance of the body.

Highest carbohydrate content (76.70%) was observed for 100 % millet biscuit (MCP1). This could be due to the fact that the biscuit is composed mainly of millet flour which has high carbohydrate content. Carbohydrate contents of formulated biscuits decreased from 76.70 % to 61.33 % as level of millet flour substitution decreased. This implies that increased supplementation with legume (cowpea) and reduced levels of cereal flour resulted in a reduction in carbohydrate contents and consequent increase in protein content.

The energy values of the formulated crackers ranged from 341.34 to 348.34 Kcal. Protein, fat and carbohydrate values contributed to the energy value of the crackers. Crackers are energy-giving foods which are consumed by both young and old, especially in-between meals. Supplementation with cowpea flour contributed to reduced caloric contents thus, the crackers may be useful to consumers with health challenge requiring low carbohydrate content foods.

Mineral composition of crackers made from millet, cowpea and unripe plantain flour blends

The results for quantitative determination of crackers for some minerals is shown in Table 5.

Zinc content ranged from 0.35 to 6.83 mg/100g, there were significant ($p<0.05$) differences among the crackers in zinc content. Zinc content increased with increase in the addition of cowpea and unripe plantain. Samples MCP5 had the highest (6.83cmg/100g) zinc content. The recommended daily intake of zinc for adults is 8 mg for women and 11mg for men[51] and this values observed in this study are lower than the recommended zinc intake although zinc can be obtained from other foods consumed by an individual. Zinc is a trace mineral element that is essential for important biochemical functions and necessary for maintaining health throughout life[52].This implies that sample MCP5 will be required more by the aged because it contains the highest amount of the minerals.

From table 5.

Magnesium content of the crackers samples were in the ranges of 16.33 to 26.14 mg/100g. There were significant ($p< 0.05$) differences amongst the samples. As the level of cowpea increased it was observed that magnesium content also increased. This shows that cowpea increased the amount of magnesium in the crackers. Magnesium can play a protective role against cardiovascular disease and stroke[53]. Without magnesium, calcium may not be fully utilized, and under-absorption problems may occur resulting in arthritis, osteoporosis, among others[52].

Potassium content of the formulated crackers ranged from 36.35 to 73.48 mg/100g. The lowest value was observed in the control sample. This may be attributed to the presence of cowpea flour and unripe plantain flour present in all the samples except the control samples. Cowpea and unripe plantain flour are high in potassium with unripe plantain and cowpea containing 120 mg/100g and 278 mg/100g potassium respectively as reported by[54] for the contribution of plantain to diets. Potassuim is known to help nerves function properly, muscles contract and heartbeat stabilize. A diet adequate in potassium will help to control some of the harmful effects of sodium.

Calcium content obtained for crackers ranged from 63.33 to 80.00 mg/100g. Significant ($p<0.05$) differences were observed among the samples although there were no significant ($p>0.05$) differences among samples MCP1, MCP2 and MCP3 containing no cowpea and less quantities of cowpea. Calcium content of the crackers increased as the level of cowpea increased and also because of the presence of unripe plantain. About 100g of these formulated products can provide more than 10 % of the recommended calcium intake. The current recommended nutrient intake (RNI) for calcium is 1000 mg a day for an adult[51].

Vitamin composition of crackers made from millet, cowpea and unripe plantain flour blends

The results for determination of vitamin contents of crackers are shown in Table 6. Beta carotene contents ranged from 5.42 µg/g to 9.85 µg/g. There were significant ($p<0.05$) differences among the samples in beta carotene content. However, the control samples had the lowest values. The higher values in all the other samples can be attributed to the contributions of cowpea flour, which is a good source of beta carotene. Unripe plantain flour also has a high beta carotene value of 63 µg[55].

Vitamin C contents ranged from 6.32 mg/100g to 10.53 mg/100g. There were significant ($p<0.05$) differences among the samples. However, the control sample (MCP1) was observed to have the lowest value. The higher values in the other samples can be attributed to the effect of blending millet with cowpea and unripe plantain flours although none of the constituents of the blends are known sources of vitamin C, but the contributions of each constituent improved the vitamin c content of the resultant crackers.

Vitamin B1 (Thiamine) contents of the produced crackers ranged from 1.40 to 2.45 mg/100g. Significant ($p<0.05$) differences was observed in vitamin B1 content of the crackers. Consumption of 100g of these crackers can provide the US RDA for adults (1.5 - 1.6 mg/100g)[56].

Phytochemicals composition of crackers made from blends of millet, cowpea, and unripe plantain flour blends

The results of the phytochemical composition of the crackers are shown in Table 7.

Flavonoid content of the crackers samples was observed to be in the range of 0.08 mg/100g to 0.11 mg/100g. There was no significant ($p >0.05$) difference in the values obtained. It was observed that the flavonoid content of the crackers samples decreased as the quantity of cowpea increased. This is an indication that millet contains more flavonoids than cowpea and unripe plantain. Flavonoids are important for human health because of their antibacterial, antiviral and anti-inflammatory activities. They also act as free radical scavengers as they are potential reducing agents that protect from oxidative damage (antioxidant).

Phenolic content of the crackers ranged from 0.98 mg/100g to 1.41 mg/100g, with the lowest values observed in sample MCP2 (containing 80 % millet, 10% cowpea and 10 % unripe plantain). Significant ($p<0.05$) differences existed among the samples in phenol content. Phenolic compounds are important in defense responses, such as anti-aging, anti-inflammatory, and antioxidant activities[57].

Alkaloids content of the crackers ranged from 1.08 % to 12.58 %, with the lowest values observed in the control sample (MCP1) containing 100% millet. Significant ($p<0.05$) differences existed among the samples. The alkaloid contents increased with increase in cowpea addition, this shows that cowpea contains higher alkaloid levels. It has been reported that alkaloids can block carcinogenic substances and can repair DNA damage in the cell. Alkaloids also have adverse effects. It has been reported to disrupt transmission of nerve impulses, and can react with cellular components causing cellular toxicity[57]. These activities are dose dependent and various processing operations and activities are known to reduce the levels of alkaloids in food products.

V. Conclusion

Blending of millet with cowpea and unripe plantain improved the chemical composition of the crackers. Sample MCP5 which contained 50%millet, 40% cowpea and 10% unripe plantain was the best sample, and is recommended for health conscious individuals.

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