

# Use of Unripe Whole Plantain in Stiff Dough Production: Nutritional, Physicochemical and Consumer Acceptability of unripe plantain Sorghum Flour Product

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## ABSTRACT

**Background:** There is global increase in demand for plantain because of diversified research interest and evolution of new products from plantain fruit.

**Objective:** This work was designed to investigate nutritional and physicochemical properties of unripe whole plantain sorghum flour, and acceptability of the stiff dough.

**Methods:** Proximate, mineral, functional, pasting and microbial analyses were carried out on composite flour at ratios 90:10, 80:20, 70:30 and 60:40 for unripe whole plantain flour and sorghum flour, respectively. Sensory characteristics of stiff dough prepared from this product were also evaluated.

**Results:** Moisture content, crude protein and total ash increased from 9.21 to 9.51%, 6.44 to 7.61% and 2.27 to 3.89% respectively as sorghum inclusion increases while crude fibre decreased from 1.61 to 1.09% as proportion of peel decreases. There was significant decrease in calcium (26.62 to 17.60 mg/100g), magnesium (149.08 to 123.77 mg/100g), potassium (945.07 to 620.56 mg/100g) and sodium (269.12 to 224.76 mg/100g) as unripe whole plantain decreases. At 5% level of significance, there was no significant difference in bulk density and water absorption capacity. Peak, trough, breakdown and final viscosity significantly decreased from 7631.5 to 5391.5 RVU, 4885 to 3883 RVU, 2746.5 to 1508.5 RVU and 6052.5 to 5026 RVU respectively as unripe whole plantain decreases. Microbial growth was within recommended aerobic count in ready-to-eat food products. There was no significant difference ( $p>0.05$ ) in mouldability and overall acceptability of the products.

**Conclusion:** Stiff dough made from 80% whole unripe plantain flour and 20% sorghum flour was most acceptable and therefore, recommended.

**Keywords:** plantain, peel, sorghum, dough, analysis

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## INTRODUCTION

Plantain (*Musa paradisiaca* L.) is one of African tropical fruit that constitute a staple food crop in central and West Africa. Nigeria is one of the largest plantains producing countries in the world. The country's annual plantain production is about 3.1 million metric tons, which makes it the second-largest producer in West Africa after Ghana [1]. It is a good source of carbohydrate, vitamins and minerals. Plantains are harvested at matured stage and ripen within 2-7 days. Due to its high moisture content, plantain is processed by grilling, frying,

boiling and drying at different maturity stage [2]. Unripe plantain is used in recent time in food processing due to its nutritional composition and less sugar in the unripe fruit, it serves as composite flour in many food industries. Unripe plantain has low sodium level that makes it ideal for hypertensive patients. Plantain contains functional component with high dietary fiber that are present in human diets to lower serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure, ulcer, appendicitis and many other diseases [3-5].

Research reports have shown that plantain peels contain bioactive compounds such as flavonoids, tannins, phlobatannins, alkaloids, glycosides, anthocyanins, and terpenoids, as well as phenolic compounds that possess high antioxidant, antibacterial, antihypertensive, antidiabetic, and anti-inflammatory activities [6, 7]. These therapeutic properties promote its utilization in the nutraceutical and pharmaceutical industries. Bioactive compounds have significant therapeutic potential due to their high antioxidant activities which confer various health benefits such as prevention of the risk of cardiovascular disease, cancer, diabetes, and obesity [8]. Furthermore, it is a good source of amino acids [9].

Sorghum (*sorghum bicolor* (L) Moench) is a staple food for many communities and is indigenous crops to Africa. Sorghum ranks fifth in the cereals crop globally after maize, wheat, rice and barley [10]. Sorghum is a major food crop in the dry parts of Africa, China and India [11]. In Africa, Nigeria is the leading sorghum producer followed by Ethiopia. Sorghum consists of carbohydrate, protein, dietary fiber, good source of minerals, vitamins, and rich source of antioxidants [12]. Sorghum serves as staple foods for celiac patients, to lower blood cholesterol, and natural cure for diabetes. Sorghum grain generally has a low starch digestibility among cereals and has potentials to be used as an ingredient for low-glycemic food [13]. This research was to determine the nutritional and physicochemical properties of whole unripe plantain sorghum flour; and to evaluate sensory acceptability of stiff dough products made from the flour.

## MATERIALS AND METHODS

### Materials

The unripe plantain and sorghum grains were purchased from Arena Market, Oshodi, Lagos, Nigeria. The raw materials were then taken to laboratory for further processing into flour. All reagents and apparatus used in this work were obtained from Food Processing Laboratory, Bells University of Technology, Ota, Nigeria.

### Processing

### method

Unripe plantain fruits were sorted and washed. Both unripe whole plantain and unripe peeled plantain were separately sliced and dried in a cabinet dryer at 60°C for 24 hours. The chips were milled using burr mill into flour, sieved with screen size 0.001m apertures, packaged in an air tight polytene container and kept at ambient temperature for

further use. The sorghum was sorted to remove dirt and foreign materials, washed severally with clean water, dried in a cabinet dryer to a moisture content of 10 - 12% and the grains were dried milled using bur mill; sieved with screen size 0.001m apertures, and then packaged in an air tight polytene container at ambient temperature until ready for use.

### Formulation of unripe plantain-sorghum composite flour

Composite flour was prepared from different proportion of whole unripe plantain flour and Sorghum flour. Unripe plantain without peel, AAA (100%) was used as control while experimental samples were PAS: 90% whole plantain flour + 10% sorghum flour; BPS: 80% whole plantain flour + 20% sorghum flour; CSP: 70% whole plantain flour + 30% sorghum flour; PSD: 60% whole plantain flour + 40% sorghum flour.

### Preparation of stiff dough

The dough was produced using the method described by Calvin [14]. The dough was prepared using 350g of plantain-sorghum flour which was added into boiling water (900 mL) in a coking utensil. The paste formed was continuously stirred and kneaded until thick homogenous dough was formed. The stiff dough formed was moulded into spherical shapes and wrapped in a clean transparent polyethylene. The product was stored in a thermo flask for 1 hour during which analysis was done.

### Proximate analysis

A standard procedure by AOAC [15] was used to determine the proximate composition such as moisture content, crude protein, crude fat, crude fiber, ash and carbohydrate content of Plantain-sorghum composite flour samples.

### Determination of mineral content

Mineral content was determined using atomic absorption spectroscopy (AAS) described by AOAC [15]. The samples were dissolved in an aqueous solution. This solution was placed in the instrument where it was heated to vaporize and atomize the minerals. A beam of radiation was then passed through the atomized sample, and the absorption of radiation was measured at a specific wavelength corresponding to the minerals: magnesium (285.2 nm), calcium (422.7 nm), potassium (766.5 nm), iron (248.3 nm), sodium (330.2 nm) and phosphorus (214.9 nm).

### Determination of functional properties

Bulk density of the flour samples was determined by weighing 25 mL capacity graduated measuring cylinder and the volume was recorded as s-loose volume, gently rolling the cylinder with the sample and tapping the bottom of the cylinder on the bench repeatedly until there was no further diminution of the sample level [16]. The volume is expressed as g/mL. Water absorption capacity was determined by weighing One (1) g of each flour sample into a dry, clean centrifuge tubes and 10 ml of deionised water was introduced. This was mixed thoroughly by vortexing and then centrifuged at 3500 g for 30 min. The supernatant was discarded and the tube with the water-absorbed sample was reweighed [17]. The water absorption capacity of each sample was expressed in g/g dry basis. The approach outlined by Jimoh and Popoola [18] was used to determine swelling power and solubility capacity.

### Determination of pasting properties

A paste was formed in weighed canister from each composite flour sample using sample mass and volume of water calculated using the moisture content of the samples. The canister with the formed paste was mixed into the Rapid Viscos Analyzer (RVA). Each suspension was kept at 50°C for 1 minute and then heated to 95°C in 7 minutes with a holding time of 5 minutes followed by cooling to 50°C in 7 minutes with 1 minute holding time. The pasting parameter (Peak viscosity, Trough viscosity, Breakdown viscosity, Final viscosity, setback viscosity, pasting time and pasting temperature) were determined by pasting profiles [19].

### Microbiological analysis

In each sample, 0.1ml was added to 90 ml 0.9 % saline to make stock solution. This formed the initial dilution from which subsequent ten-fold dilutions were made and used for analysis. Portion (0.1 ml) of the third diluent ( $10^{-3}$ ) was pour plated on Nutrient agar for total plate count, fungi and bacteria count for Potato dextrose agar, Feecal streptococcus for blood agar and total coliform count for MacConkey agar. Analysis was carried out under aseptic conditions. Plates were incubated for 24 hours at 37°C for bacterial count and 48 hours at 25°C for fungi count. Colonies were counted and multiplied by dilution factor and expressed as CFU/ ML sample.

### Sensory evaluation

Nine points hedonic scale where 1 represent

“extremely dislike” and 9 represents “extremely like” was used. The organoleptic evaluation of the dough samples was carried out by using 20 semi trained panelists. The properties evaluated were the colour, aroma, mouldability, consistency, mouthfeel and overall acceptability of stiff dough.

### Statistics analysis

All data obtained from the study was subjected to analysis of variance (ANOVA) and means was separated using Duncan's multiple range test. Statistical package for the social sciences software version 24 was used for all statistical analysis at a significant level of  $P < 0.05$ .

## RESULTS

### Proximate composition of plantain–sorghum composite flours blends

Results of proximate composition of plantain–sorghum composite flours were presented in Table 1. As inclusion of sorghum increases; moisture content of composite flours increased from 9.21 to 9.51%, crude protein increased from 6.44 to 7.61%, crude fibre decreased from 1.61 to 1.09% and total ash increased from 2.27 to 3.89%. After 20% inclusion of sorghum, crude fat significantly increased from 1.10 to 2.17% while at 5% level of significance, carbohydrate in the samples showed no significant difference.

### Mineral composition of plantain–sorghum composite flour blends

The mineral composition of the plantain–sorghum composite flour samples is presented in Table 2. The result showed that there was significant difference ( $p < 0.05$ ) in the mineral composition of the composite flour. The range of mineral composition (mg/100g) for calcium, magnesium, Potassium, sodium, phosphorus and iron are 13.30 to 26.62, 123.77 to 149.11, 620.56 to 945.07, 203.26 to 269.12, 10.99 to 66.05 and 19.66 to 42.07 respectively.

### Functional properties of plantain–sorghum composite flour blends

Table 3 presents the functional properties of the plantain-sorghum flour blends. The result showed 0.63 to 0.66 g/ml bulk density, 2.60 to 2.70% water absorption capacity, 6.86 to 9.64 g/g swelling power and 1.81 to 3.43 % solubility power. There were no significant differences ( $p > 0.05$ ) in water absorption capacity but solubility capacity showed significant differences ( $p < 0.05$ ) among samples at 5% level of significance.

**Table 1: Proximate composition of plantain sorghum composite flour blends**

Sample	Moisture Content (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbohydrate (%)
AAA	7.17 <sup>c</sup> ±0.02	6.10 <sup>b</sup> ±0.04	0.98 <sup>e</sup> ±0.03	0.23 <sup>c</sup> ±0.04	1.48 <sup>e</sup> ±0.02	84.08 <sup>a</sup> ±0.24
PAS	9.21 <sup>b</sup> ±0.03	6.44 <sup>b</sup> ±0.03	1.49 <sup>c</sup> ±0.01	1.61 <sup>a</sup> ±0.03	2.27 <sup>d</sup> ±0.04	78.97 <sup>b</sup> ±0.16
BPS	9.25 <sup>b</sup> ±0.02	6.45 <sup>b</sup> ±0.03	1.10 <sup>d</sup> ±0.01	1.57 <sup>a</sup> ±0.03	2.48 <sup>c</sup> ±0.01	79.16 <sup>b</sup> ±0.24
CSP	9.49 <sup>a</sup> ±0.05	7.58 <sup>a</sup> ±0.04	2.11 <sup>b</sup> ±0.03	1.11 <sup>b</sup> ±0.01	2.81 <sup>b</sup> ±0.04	76.90 <sup>b</sup> ±0.12
PSD	9.51 <sup>a</sup> ±0.06	7.61 <sup>a</sup> ±0.01	2.17 <sup>a</sup> ±0.03	1.09 <sup>b</sup> ±0.02	3.89 <sup>a</sup> ±0.02	75.73 <sup>b</sup> ±0.31

Values are means of triplicate samples ± standard deviation. Means with different lower-case letters are significantly different (p<0.05).

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole plantain flour+40% sorghum flour.

**Table 2: Mineral composition of plantain-sorghum composite flour blends**

Sample	Calcium (mg/100 g)	Magnesium (mg/100 g)	Potassium (mg/100 g)	Sodium (mg/100 g)	Phosphorus (mg/100 g)	Iron (mg/100 g)
AAA	13.30 <sup>e</sup> ± 0.04	149.11 <sup>a</sup> ± 0.33	804.32 <sup>b</sup> ± 0.63	203.26 <sup>e</sup> ± 0.51	10.99 <sup>e</sup> ± 0.19	20.47 <sup>d</sup> ± 0.01
PAS	26.62 <sup>a</sup> ± 0.34	149.08 <sup>a</sup> ± 0.49	945.07 <sup>a</sup> ± 0.24	269.12 <sup>a</sup> ± 0.17	37.59 <sup>d</sup> ± 0.04	27.74 <sup>c</sup> ± 0.15
BPS	20.38 <sup>b</sup> ± 0.06	148.69 <sup>a</sup> ± 0.37	938.26 <sup>a</sup> ± 78.16	261.07 <sup>b</sup> ± 0.34	45.11 <sup>c</sup> ± 0.02	28.20 <sup>b</sup> ± 0.01
CSP	19.02 <sup>c</sup> ± 0.19	144.73 <sup>b</sup> ± 0.75	634.61 <sup>c</sup> ± 0.62	230.24 <sup>c</sup> ± 0.46	55.01 <sup>b</sup> ± 0.09	42.07 <sup>a</sup> ± 0.08
PSD	17.60 <sup>d</sup> ± 0.23	123.77 <sup>c</sup> ± 0.12	620.56 <sup>c</sup> ± 0.32	224.76 <sup>d</sup> ± 0.06	66.05 <sup>a</sup> ± 0.20	19.66 <sup>e</sup> ± 0.10

Values are means of triplicate samples ± standard deviation. Means with different lower-case letters are significantly different (p<0.05).

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole plantain flour+40% sorghum flour.

**Table 3: Functional properties of plantain-sorghum composite flour blends**

Sample	Bulk density (g/ml)	Water absorption capacity (%)	Swelling power (g/g)	Solubility capacity (%)
AAA	0.66 ± 0.01	2.40 ± 0.01	10.46 ± 0.01	3.71 ± 0.12
PAS	0.65 <sup>ab</sup> ± 0.01	2.70 <sup>a</sup> ± 0.14	9.64 <sup>b</sup> ± 0.06	3.43 <sup>b</sup> ± 0.04
BPS	0.63 <sup>b</sup> ± 0.01	2.70 <sup>a</sup> ± 0.14	9.11 <sup>c</sup> ± 0.07	2.18 <sup>c</sup> ± 0.11
CSP	0.65 <sup>ab</sup> ± 0.00	2.60 <sup>a</sup> ± 0.00	6.86 <sup>d</sup> ± 0.01	1.84 <sup>d</sup> ± 0.06
PSD	0.66 <sup>a</sup> ± 0.01	2.60 <sup>a</sup> ± 0.01	9.00 <sup>c</sup> ± 0.07	1.81 <sup>d</sup> ± 0.07

Values are means of triplicate samples ± standard deviation. Means with different lower-case letters are significantly different (p<0.05).

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole plantain flour+40% sorghum flour.

### Pasting properties of plantain-sorghum composite flour blends

The pasting properties of whole plantain-sorghum composite flour are shown in Table 4. Peak, trough, breakdown and final viscosity in the samples

decreased significantly (7631.50 to 5391.50, 4885 to 3883, 2746.50 to 1508.50 and 6052.50 to 5026 RVU respectively) as sorghum inclusion increases.

**Table 4: Pasting properties of plantain sorghum composite flour blends**

Sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)	Pasting temp (°C)
AAA	6768.00 <sup>b</sup> ± 145.66	4414.00 <sup>bc</sup> ± 127.28	2354.00 <sup>b</sup> ± 18.39	5411.50 <sup>b</sup> ± 41.72	997.50 <sup>a</sup> ± 169.00	5.07 <sup>a</sup> ± 0.38	82.35 <sup>o</sup> ± 0.00
PAS	7631.50 <sup>a</sup> ± 170.41	4885.00 <sup>a</sup> ± 26.87	2746.50 <sup>a</sup> ± 143.54	6052.50 <sup>a</sup> ± 70.00	1167.50 <sup>a</sup> ± 96.87	4.93 <sup>a</sup> ± 0.00	83.13 <sup>o</sup> ± 0.04
BPS	6390.50 <sup>c</sup> ± 23.34	4439.50 <sup>b</sup> ± 102.53	1951.00 <sup>c</sup> ± 79.20	5446.00 <sup>b</sup> ± 83.44	1006.50 <sup>a</sup> ± 19.09	4.87 <sup>a</sup> ± 0.00	83.53 <sup>a</sup> ± 0.672
CSP	5801.50 <sup>d</sup> ± 149.20	4222.00 <sup>c</sup> ± 59.40	1579.50 <sup>d</sup> ± 89.80	5362.00 <sup>b</sup> ± 56.57	1140.00 <sup>a</sup> ± 2.83	4.83 <sup>a</sup> ± 0.05	81.83 <sup>o</sup> ± 0.60
PSD	5391.50 <sup>e</sup> ± 85.56	3883.00 <sup>d</sup> ± 36.77	1508.50 <sup>d</sup> ± 122.33	5026.00 <sup>c</sup> ± 74.95	1143.00 <sup>a</sup> ± 111.73	4.80 <sup>a</sup> ± 0.09	82.25 <sup>o</sup> ± 1.13

Values are means of triplicate samples ± standard deviation. Means with different lower-case letters are significantly different (p<0.05).

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole plantain flour+40% sorghum flour.

**Table 5: Microbial analysis of plantain sorghum composite flour blends**

Sample	Total plate count (CFU/g)	Fungi and bacteria count (CFU/g)	Total coliform count (CFU/g)	Faecal streptococcus (CFU/g)
AAA	1.1 x10 <sup>2</sup>	ND	ND	ND
PAS	2.1 x10 <sup>2</sup>	ND	ND	ND
BPS	1.4 x10 <sup>3</sup>	ND	ND	ND
CSP	1.3 x10 <sup>2</sup>	2.4 x10 <sup>3</sup>	ND	ND
PSD	1.1 x10 <sup>3</sup>	3.0 x10 <sup>2</sup>	ND	ND

ND – Not Detected.

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole plantain flour + 40% sorghum flour.

### Microbial analysis of plantain-sorghum composite flour blends

Result of total plate count, fungi and bacteria count, total coliform count and faecal streptococcus of plantain sorghum flour samples were shown in Table 5. It revealed that highest plate count of samples was  $1.4 \times 10^3$  CFU/g. Fungi and bacteria count were not detected in samples PAS, BPS and control sample while samples CSP and PSD were  $2.4 \times 10^3$  CFU/g and  $3.0 \times 10^2$  CFU/g respectively.

### Sensory attributes of stiff dough made from plantain-sorghum composite flour

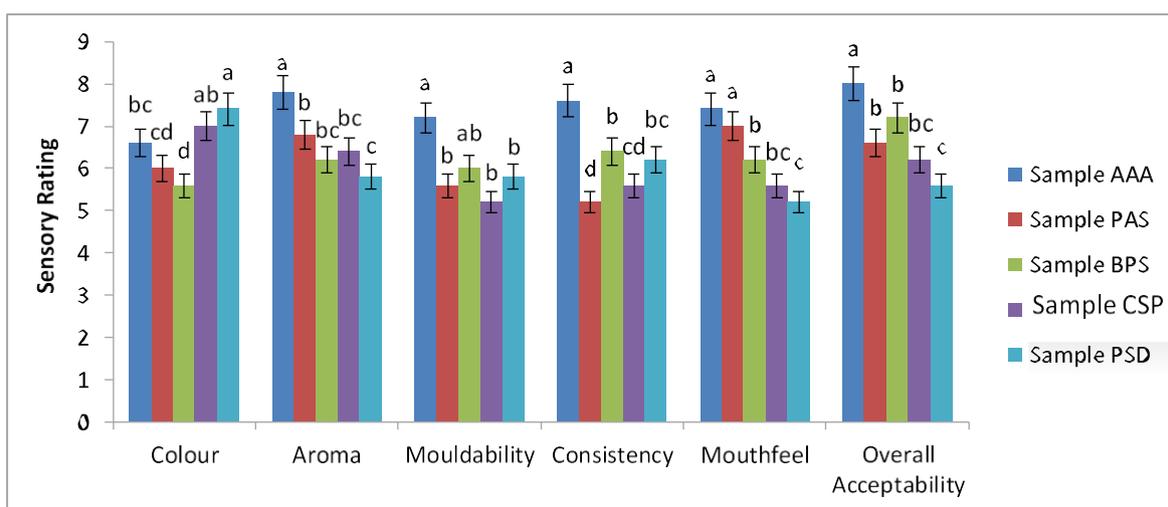
Figure 1 shows the sensory attributes of stiff dough made from unripe plantain-sorghum composite flour. The sensory analysis such as colour, aroma, mouldability, consistency, mouthfeel and overall acceptability of the stiff dough showed that control sample was rated highest in all parameters except in colour because of non-inclusion of sorghum flour and peel.

### DISCUSSION

The sample moisture content is higher than that of the control sample showing that water level in sorghum is high and this could contribute to why sorghum is preferred in brewing industries for production of beer and beverages. At 5% level of

significance, there was no significant difference ( $p > 0.05$ ) in the composite flour CSP and PSD samples except in crude fat and total ash. Generally, high-moisture products ( $> 12/100$  g) have shorter shelf stability compared to lower moisture products ( $< 12/100$  g) [20]. Increased in samples protein could be as result of relative high level of protein in sorghum. However, protein content of unripe plantain in control experiment was higher than 1.78% to 2.15% reported by Yarkwan and Uvir [21] from unripe plantain flour. This difference might be due to level of maturity before harvest and processing method. The crude fibre content is higher than the value 0.4 to 1.13% reported by Adebayo-Oyetero et al. [22]. High value of fibre in the samples could be effect of plantain peel. Ash content is obviously higher than 2.71 to 5.25 % reported by Azeez et al. [23]. This could be as a result of processing method.

The decrease in the calcium, magnesium, potassium and sodium content of the samples as sorghum flour inclusion increases could be attributed to decrease in plantain peel in the samples and this was supported by Bolarinwa et al. [24] who reported calcium content of 6.55 mg/100 g from malted sorghum-soy composite flour. Moreover, control experiment indicated that magnesium 149.11 mg/100g and potassium



**Figure 1: Sensory attributes of stiff dough made from plantain-sorghum composite flour**

Means with different lower-case letters are significantly different ( $p < 0.05$ ).

AAA: 100% unripe plantain without peel; PAS: 90% whole unripe plantain flour+10 % sorghum flour; BPS: 80% whole unripe plantain flour+20% sorghum flour; CSP: 70% whole unripe plantain flour+30% sorghum flour; PSD: 60% whole unripe plantain flour+40% sorghum flour.

804.32 mg/100g were higher than 30.65 mg/100g and 71.62 mg/100g for magnesium and potassium respectively reported by Adegunwa et al. [20]. This could be as result of soil composition, environment factors and processing method. At 5% level of significance, there were significant differences ( $p < 0.05$ ) in the mineral composition of the samples. This might be directly linked to the dilution effect of a lower quantity of these minerals in sorghum flour which subsequently causes reduction of mineral content in higher inclusion.

Bulk density of sample PSD is significantly higher than other samples but showed no difference with control sample and this could be as a result of high specific gravity of plantain peel and that of sorghum. Higher bulk density is advantageous for its great ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding; while low bulk density would be desirable in the formulation of weaning foods. The lower the bulk density value, the higher the amount of flour particles that can stay together thus increasing the energy content that could be derivable from such diets [25]. High water absorption capacity in the samples could be traced to effect of high fibre in peel to entrap large amount of water to enhance food swelling and consistency. However, this result was compared favorably with the result of Amah et al. [3] who reported 2.30 to 3.45 %. Decrease in swelling power of samples could be as result of sorghum flour inclusion and this significantly decreased as sorghum level increases. Apparently, solubility capacity decreased with increase in sorghum flour inclusion and showed relative significant difference at 5% level of probability.

Peak viscosity of the samples 5391.50-7631.50 RVU was higher than 842-1727 RVU reported by Ajala et al. [26]. Trough viscosity of flour samples 3883-4885 RVU was higher than 312.50 RVU obtained by Adegunwa et al. [20]. This could be due to variability, growing condition and age of the crop. High initial viscosity indicates ability of the flour to form a firm, visco-elastic paste or gel after cooking and cooling owing to the re-association of starch molecules and high resistance to shear stress during processing [27]. High setback viscosity of samples suggests tendency to become firmer with increasing

resistance to enzymatic attack, thus reduce dough digestibility and causes staling of products made from the flour. Peak time (5.07 minutes) and pasting temperature (82.35°C) of control sample were closely related to 5.47 minutes peak time and 89.60°C pasting temperature reported by Adegunwa et al. [20]. At 5% level of significant, there was no significant differences ( $p > 0.05$ ) in setback viscosity, peak time and pasting temperature of the samples. In other word, the samples have tendency for starch retrogradation and to become firmer with increasing resistance to enzymatic attack. Result of pasting temperature implies that initial changes that occur during swelling of starch is the same among samples.

Recommended microbial growth in ready to eat food product is  $< 10^6$  CFU/g [28]. However, fungi and bacteria count obtained in this research were within acceptable aerobic count in food product guideline. Experimental result of this study depicts that coliform and faecal streptococcus counts were not detected in the samples. Investigation revealed that maximum moisture content for the growth of coliform bacteria is 18% [29], but the highest moisture content recorded in this research was found in sample PSD with moisture content 9.51% and this could be unfavorable for the growth of coliforms.

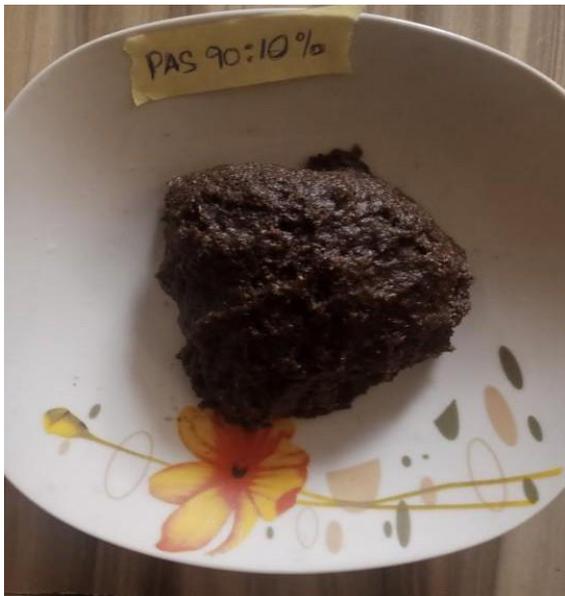
Textural properties such as mouldability and sticky nature of the dough necessitates how well it gels during swallowing and mouthfeel. From the experimental results; dough made from 90% whole unripe plantain flour and 10% sorghum flour gave highest mouthfeel and aroma. Dough made from 80% whole unripe plantain flour and 20% sorghum flour gave highest mouldability and consistency while stiff dough prepared from both 90% and 80% whole plantain flours showed highest overall acceptability and have no significant difference. Thus, this performance could be as result of high proportion of peel since more fibre is contained and recorded in these two samples. It was noted that at 5% level of significance, samples showed significant difference ( $p < 0.05$ ) in colour, consistency and mouthfeel. Dark colour noted in the samples presented in Figure 2 could be as result of organic compounds such as iridoids found in green (unripe) plantain peel that responsible for its strong bioactive compound [6].



AAA



CSP



PAS



PSD



BPS

**Figure 2: Stiff dough made from plantain-sorghum flour**

## CONCLUSION

In this part of the world where plantain peel is either considered as waste or as animal feed, this research findings provides significant justification from waste to wealth action for the sustainable development goals. High protein and fibre content reported in stiff dough made from whole unripe plantain-sorghum composite flour established nutritional potential of the product as alternative staple food over stiff dough made from unripe plantain without peel. This study also revealed that dough prepared from whole unripe plantain blended with sorghum is rich in carbohydrate, fibre and protein and when this is swallowed, it may helps to reduce protein malnutrition, increase energy intake, lower cholesterol and keep digestive system healthy. The products are microbial stable and within the range of global acceptability. From consumers' point of view, stiff dough made from 80% whole unripe plantain and 20% sorghum composite flour sample was most preferred and therefore, recommended.

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