Pasting and Nutritional Properties of Three Unripe Banana Species Flours and Acceptability of Pastes Produced from the Flours

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ABSTRACT

Background: *Unripe banana flours and pastes are incredibly nutritious and can serve as a good source of fibre, resistant starch, minerals and vitamins.*

Objective: *The overall objective of this study was to determine the nutritional and pasting properties of flour samples made from some unripe banana species (Red banana, Blue java and Cavendish specifically the study determined the chemical composition, minerals, physico-chemical , functional properties of the flour samples and acceptability of thick pastes (Amala) produced from them.*

Methods: *Proximate composition, energy values, minerals and pasting properties were determined using standard methods. Data were analyzed using SPSS version 20, and significance was accepted at 5% level. The sensory attributes of the pastes (Amala) were determined using Hedonic and multiple comparison.*

Results: *Moisture, ash, protein, fat , crude fibre, total Carbohydrate and Energy ranged from 4.68-7.20 %, 1.17 to 2.67 %, 0.58 to 1.03 %, 0.80 to 2.07 %, 0.04 to 0.83 %, 88.77 - 89.51%, 3.73 -3.77 kcal respectively. The mineral contents of the four samples ranged from 1.18 to 37.67 mg/kg(Magnesium), 0.69 to 22.52 mg/kg(Potassium), 1.08 to 14.32 mg/kg(Sodium), 1.14 to 25.14 mg/kg(Zinc) and 0.74 to 25.01 mg/kg(Iron).. The peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity and peak time ranged from 221.12 to 260.04 RVU, 154.42 to 173.46 RVU, 66.71 to 96.17RVU, 240 to 301.21RVU, 85.58 to 143.04RVU and 5.1 to 5.27 minutes respectively. Pasting temperatures ranged from 86.03 and 88.88oC.*

Conclusion: *The sensory acceptability test for the pastes indicated that Red banana was the most accepted species*

Keywords: Unripe banana, Nutritional properties, Pastes, Sensory- acceptability.

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Introduction

The two main categories of Bananas (*Musa sp*) are those used in cooking and dessert. Dessert varieties are consumed fresh when ripe, while cooked (starchy) Bananas and plantains are boiled, fried, brewed, roasted for consumption or powdered for making gruel (paste) and as a baking ingredient (1). Several studies have suggested that consumption of unripe bananas are beneficial to human health, a fact often associated with its high resistant starch (RS) content, which ranges between 47% and 57% (2). Recently, the preparation of unripe banana flour was described, with 73.4% total starch content, 17.5% RS content and a dietary fibre level of 14.5% (3). Additionally, unripe banana flour might be an important source of polyphenols, compounds that are regarded as natural antioxidants (4). Banana flour made from dehydrated or naturally dried green banana are used as substitute flour in many dishes including gluten free meals. The common practice is to dry banana first before milling them into flour because of its relatively high proportion of resistant starch, which has been recommended for the dietary control of diabetes mellitus and other related disorders (5,6). However, banana is not commonly used for main meals but as fruit, plantain flour on the other hand, is used in making good stiff dough called *Amala* either singly or in combination with yam flour (7). *Amala,*is primarily consumed in the South Western region of Nigeria and in a small portion of Ghana, where it is known as *Kokonte* (8). According to Awoyale *et al.,* (9), *amala* from yam is primarily composed of carbohydrates, it does not adequately supply nutrients, especially to people who live in rural areas. Therefore, efforts are being made to increase the nutritional content of such staples by including plantain and banana (Musa sp.). Presently, plantain flour is used as paste (Amala) as discussed and little or no use of banana for *amala* is reported in literature. This study aims to determine the nutritional and pasting properties of common unripe banana species flours and the consumer acceptability of their pastes (*Amala*).

MATERIALS AND METHODS

Procurement of materials

The materials used for this research; Unripe Banana (3 species: Red banana, Blue java banana and Cavendish banana) and Plantain (Laboratory sample and market sample) were purchased from a local market in Iwo, Osun state' Nigeria. All chemicals used, were of food quality grade. All equipment were obtained from the Food Science and Technology programme Laboratory, Bowen University, Iwo, Osun state, Nigeria

Identification of the samples

The banana species were identified in Nigeria Institute of Horticultural Research(NIHORT), Ibadan, Oyo state,

Preparation of Banana flour

Banana and Plantain were processed in batches. The fruits chosen,had acceptable appearance for consumption. They were cleaned, peeled and rinsed with large amounts of tap water, and manually sliced 0.5-1" thick, to be used in the production of flours with four different schemes. Each specie was labelled accordingly and put into a dehydrator to dry at 60 °C for 52hours. The dried banana and plantain slices were milled with a grinding machine, sieved through 250µm aperture sieve and stored in Zip lock bags for further analysis (10).

Analysis of the banana and plantain flours

Proximate composition of the flour samples:

Proximate analyses were carried out using the methods described by AOAC (11). Total carbohydrate was determined by difference.

% Nitrogen Free Extract = 100% - (Moisture + Crude Fat + Crude Protein + Ash + Crude Fibre)

Determination of Mineral contents

The mineral content was determined as described by A.O.A.C (11). Two gramme of the sample was heated. To eradicate any organic materials, this was burnt in a fume cupboard over a Bunsen flame. The heated sample was then heated for another 4-6 hours in a muffle furnace at around 550°C until white ash remained. Five millilitres of 6M HCL was mixed with the ash and made up to 50 mL with distilled water. Blank experiment was carried out for background correction using distilled water and following the procedure described above without sample. Digested samples were analyzed using Buck scientific model PG 990 Flame Atomic Absorption Spectrophotometer Magnesium (Mg), Iron (Fe), Potassium (K), Sodium (Na) and Zinc (Zn) were determined. The concentration of the elements were calculated using the formula below:

Mineral content (mg/kg) = Actual concentration (ppm) * Dilution factor

Energy Value of the banana and plantain flours

Energy content of chocolates were calculated and expressed as kilocalories (kcal) (12). The energy present in the samples were calculated using the formula given below:

Energy (kcal) = (4 x Protein) + (4 x Total carbohydrates) + (9 x Fat) .... (2)

Pasting properties of the flour samples

The flours were analyzed for their pasting properties using Rapid Visco–Analyser at the Mini laboratory, Bowen University, Iwo, Nigeria. Pulverized samples of 3.5 g each were weighed and 25 mL of distilled water was dispensed into a canister. Paddle was placed inside the canister and then inserted into the RVA. The measurement cycle was initiated by pressing the motor tower of the instrument. The profile was monitored on a computer connected to the instrument. Thirteen minutes profile was used. The time–temperature regime used was: idle temperature for 50 °C for 1 min, heated from 50 °C to 95 °C in 3 min 45 sec, then held at 95 °C for 2 min 30 sec; the samples were subsequently cooled to 50 °C over a period of 3 min 45 sec followed by a period of 2 min while the temperature was controlled at 50 °C.

Sensory evaluation of the pastes (Amala) produced from plantain and banana samples.

Thirty trained sensory panelist members were used to evaluate the sensory properties of the paste made from the flour samples. A 9-point hedonic scale was used to evaluate sensory properties using the following quality parameters- taste, mouth feel, aroma, color and overall acceptability. The participants sat around the rectangular tables. A bottle of table water was made available for the panelist to rinse their palate in between samples after tasting. Instructions were given to the panelists and the samples were coded using AD14, ZE27,JA17, DK47 and RAD. The samples were randomly served to the panelists for unbiased judgment. Each sensory attribute was scored on a 9-point hedonic scale where 9 stands for Like Extremely and 1 stands for Dislike Extremely.

Statistical analysis

All samples were analysed in triplicate. The results were expressed as the mean ± standard deviation. Statistical analysis was carried out using one-way analysis of variance (ANOVA). Data were analysed using SPSS, version 20, 2017

Ethical approval was obtained from Bowen University Teaching Hospital (BUTH) Research Ethics Committee with registration number : NHREC/12/0422 and approval number BUTH REC-1063. Consent to participate as a memmber of taste panelist was obtained verbally after the training of the panel members.

RESULTS

Proximate Composition of the plantain and banana Flour Samples

Table 4.1 shows the values for the proximate composition of the plantain and banana flour samples. The moisture, ash, fat, protein, crude fibre and total carbohydrate contents ranged from 4.68% (cavendish banana) to 7.20 %(market sample); 1.17%(market sample) to 2.83% (Cavendish); 0.80%(market sample) to 2.07 %(red banana); 0.58%(market sample) to 1.03 %(red banana), 0.04%(market sample) to 0.83 %(red banana) and 88.77%(red banana) to 91.06%(laboratory sample) respectively. The moisture contents, ash contents, protein and fat contents were significantly different ($p<0.05$) for each of the samples of blue java banana, laboratory sample plantain, plantain market samples, Cavendish banana and red banana. There was no significant difference among the

Table 1. Proximate composition of plantain and banana flour samples (%)`

SAMPLE	MOISTURE (%)	ASH (%)	FAT (%)	PROTEIN (%)	FIBRE (%)	TOTAL CHO (%)
AD14	5.30 ± 0.79^{ab}	2.33 ± 0.29^{ab}	1.98 ± 0.29^{a}	0.88 ± 0.76^{ab}	0.30 ± 0.15^{b}	89.51 ± 0.89^{ab}
ZE27	5.93 ± 1.75^{ab}	1.50 ± 0.87^{b}	0.92 ± 0.76^{b}	0.72 ± 0.48^{bc}	0.12 ± 0.00^{d}	91.06 ± 1.35^{a}
JA17	7.20 ± 0.52^{a}	1.17 ± 0.76^{c}	0.80 ± 0.00^{c}	0.58 ± 0.75^{c}	0.04 ± 0.00^{e}	90.40 ± 1.17^{ab}
DK47	4.68 ± 0.85^{b}	2.83 ± 0.29^{a}	0.82 ± 0.58^{c}	0.75 ± 0.17^{bc}	0.23 ± 0.00^{c}	90.95 ± 0.64^{a}
RAD	4.98 ± 1.16^{b}	2.67 ± 0.29^{a}	2.07 ± 0.58^{a}	1.03 ± 0.45^{a}	0.83 ± 0.00^{a}	88.77 ± 1.13^{a}

Values are mean± SD of triplicate; Duncan separation of means with same alphabets are not significantly different ($p<0.05$) in each column. AD14: Blue java banana, ZE27: Plantain produced in the lab, JA17: Plantain market sample, DK47: Cavendish banana, RAD: Red banana.

Table 2: Energy values of Flour Samples (kcal/100 g)

SAMPLE	ENERGY VALUE
AD14	3.73 ± 3.77
ZE27	3.77 ± 5.38^{a}
JA17	3.74 ± 4.40^{a}
DK47	3.77 ± 3.20^{a}
RAD	3.70 ± 4.68^{a}

Values are mean± SD of triplicate; Duncan separation of means with same alphabets are not significantly different ($p<0.05$) in each column. **AD14:** Blue java banana, **ZE27:** Plantain produced in the lab, **JA17:** Plantain market sample, **DK47:** Cavendish banana, RAD: Red banana.

samples for carbohydrates.

Energy value of the flour samples

The energy value(Table 2) of the flour samples ranged from 3.70 kcal (red banana) to 3.77 kcal (cavendish banana and plantain flour produced in the laboratory). The enegy values ranged from 3.70(red banana) to 3.77kcal/100 g(plantain sample and cavendish banana). There was no significant difference ammong the values($p<0.05$)

Mineral compositions of Flour samples

The mineral composition of the flour samples are as shown in Table 3. They are as follows: 1.18 mg/kg(cavendish banana) to 37.67 mg/kg(blue java) for Magnesium; 0.69 mg/kg(market sample plantain) to 22.52 mg/kg(blue java) for Potassium; 1.08 mg/kg (blue java) to 14.32 mg/kg (javendish banana) for Sodium; 1.14 mg/kg (blue java) to 25.14 mg/kg (market sample plantain flour) for Zinc and 0.74 mg/kg (Cavendish banana) to 25.01 mg/kg (red banana) for Iron.

Pasting properties of banana and plantain flour samples

Table 4 shows the results for pasting properties of the banana and plantain flours. The peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity and peak time ranged between 221.12 RVU(red banana) and 260.04 RVU(blue java); 154.42 RVU (red banana) and 173.46 RVU (plantain flour produced in the laboratory); 66.71 RVU (red banana) and 96.17 RVU (blue java);240 RVU (red banana) and 301.21 RVU (Cavendish banana), 85.58 RVU (red banana) and 143.04 RVU (blue java), 5.1 minutes (red banana) and 5.27 minutes(plantain flour produced in the laboratory) respectively. Pasting temperature ranged from 86.03°C (plantain flour from the market) and 88.88°C (blue java).

Sensory acceptability of the Paste (Amala) made from the flour samples

Table 5 shows the mean sensory scores of the Paste produced from the flour samples. Scoring for colour ranged from 6.40 to 7.47. The paste *(amala)* prepared using all samples were not significantly different from each other. However, Red banana had the highest rating of 7.47 while plantain (market sample) had the lowest rating of 6.40 in colour

Texture ranged from 5.93 to 7.40 with red banana

Table 3: Mineral Composition of banana Flour Samples (mg/kg)

SAMPLE	MAGNESIUM (Mg)	POTASSIUM (K)	SODIUM (Na)	Zinc (Zn)	Iron (Fe)
AD14	37.67±0.28[a]	22.52±0.00[a]	1.08±0.00[e]	1.14±0.00[e]	1.67±0.28[c]
ZE27	13.27±0.03[c]	0.82±0.00[d]	14.32±0.01[b]	1.52±0.00[c]	16.42±0.00[b]
JA17	1.22±0.00[d]	0.69±0.00[e]	1.17±0.03[d]	25.14±0.00[a]	0.79±0.01[d]
DK47	1.18±0.02[d]	1.20±0.01[b]	14.44±0.01[a]	1.18±0.02[d]	0.74±0.01[d]
RAD	15.04±0.00[b]	1.14±0.01[c]	1.21±0.00[c]	1.67±0.03[b]	25.01±0.00[a]

Values are mean± SD of triplicate; Duncan separation of means with same alphabets are not significantly different ($p<0.05$) in each column. **AD14:** Blue java banana, **ZE27:** Plantain produced in the lab, **JA17:** Plantain market sample, **DK47:** Cavendish banana, **RAD:** Red banana.

Table 4. Pasting Properties of the banana species Flour Samples

sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (Min)	Pasting temperature^0 C)
AD14	260.04±0.18[a]	163.88±7.72[a]	96.17±7.90[a]	287.29±12.7[a]	123.42±20.51[ab]	5.17±0.01[ab]	88.88±0.04[a]
ZE27	257.79±2.18[a]	173.46±17.38[a]	84.58±14.85[ab]	283.88±5.95[a]	110.42±23.33[abc]	5.23±0.01[a]	88.88±0.04[a]
JA17	239.29± 2.06[c]	156.67±1.29[a]	82.625±0.77[ab]	252.08±3.89[b]	95.42±2.59[b]	5.27±0[a]	86.03±0.60[d]
DK47	244.88±1.83[b]	158.17±5.42[a]	86.71±3.59[ab]	301.21±2.30[a]	143.04±3.12[a]	5.17±0.01[ab]	87.3±0.07[c]
RAD	221.12±0.29[d]	154.42±1.53[a]	66.71±1.83[b]	240±1.30[b]	85.58±0.24[a]	5.10±0.01[b]	88±0[b]

Values are mean± SD of triplicate; Duncan separation of means with same alphabets are not significantly different ($p<0.05$) in each column. **AD14:** Blue java banana, **ZE27:** Plantain produced in the lab, **JA17:** Plantain market sample, **DK47:** Cavendish banana, **RAD:** Red banana.

Table 5 Sensory acceptability of pastes produced from flours of the banana species paste

Sample	Colour (Apperance)	Texture	Taste	Aroma	Overall acceptability
AD14	7.00 ± 1.31^a	7.00 ± 1.36^a	7.27 ± 1.22^{ab}	6.33 ± 1.72^a	7.13 ± 1.36^{ab}
ZE27	6.80 ± 1.15^a	7.07 ± 1.10^a	6.47 ± 1.41^b	5.93 ± 1.53^a	6.73 ± 1.16^b
JA17	6.40 ± 1.77^a	7.13 ± 1.25^a	6.93 ± 1.34^{ab}	6.27 ± 1.58^a	6.87 ± 1.55^{ab}
DK47	6.87 ± 1.36^a	5.93 ± 2.05^b	6.27 ± 1.87^b	6.00 ± 1.69^a	6.33 ± 1.59^b
RAD	7.47 ± 1.38^a	7.40 ± 1.00^a	7.67 ± 1.05^a	6.73 ± 1.39^a	7.87 ± 0.74^a

Values are mean± SD of triplicate; Duncan separation of means with same alphabets are not significantly different ($p<0.05$) in each column. **AD14:** Blue java banana, **ZE27:** Plantain produced in the lab, JA17: Plantain market sample, **DK47:** Cavendish banana, **RAD:** Red banana

having the highest rating of 7.40, plantain market sample with the value of 7.13, plantain lab sample with the value of 7.07, blue java banana and Cavendish banana had the value of 7.00 and 5.93 respectively. There were no significant differences between samples: blue java banana, Plantain lab sample, plantain market sample and Red banana.

For the values from assessing taste, the results showed that the means of the samples were significantly different from each other at (<0.05) level. The highest rating of 7.67 was found Red banana, On the other hand, the lowest rating was observed in sample Cavendish banana 6.27 in terms of taste. Paste sample made with plantain lab sample had the lowest rating in aroma (5.93). However, Paste sample made with Red banana had the highest rating of 6.73 in aroma. No significant differences was observed between the samples.

In terms of overall acceptability, Paste made with red banana was the most preferred by the panelists, while paste sample from Cavendish banana was the least accepted with a mean score of 6.33.

DISCUSSIONS

The observed total carbohydrate(88.77-91.06%) and fat(0.92-2.07%) contents were higher than the values(80.8 and 0.5% for carbohydrates and fat respectively) reported from literature, while the observed values for moisture(4.98- 5.93%), protein(0.58-1.03%) and fibre (0.12-0.83) were lower than those from the literature(14.31%, 3.19% and 4.2% for moisture, protein and fibre respectively) (3). this may be due to lower moisture contents, breed and locations of the banana samples.

The observed moisture content of the samples were within the range for longer storage life of less than 13%. This moisture content, will ensure a relatively long shelf life of the samples. It will also prevent rotting and proliferation of pathogenic microbes if stored at a relatively low humidity level (13,14). Ash content is usually an indicator of minerals, but could also be an indicator of the presence of some impurities present in the product. The ash content of the flour samples was lower than the value reported by Ajala *et al.*(15) for yam flour which was 3.02-3.78%.

Energy values of banana samples(3.70-3.77kcal/100 g) was less than 89 kcal/100g from the literature (3). Low energy value is required in adults who are sedentary workers since several chronic diseases such as obesity, diabetes and cardiovascular diseases have been considered to be caused by excess energy intake (2)

The magnesium content ranged from 1.18 mg/kg in Cavendish bananas to 37.67 mg/kg in Blue Java bananas. These levels were lower than the 62.90-123.86 mg/kg reported by Hardisson et al.(16), who noted that differences could be due to species, seasonal variations, and geographical locations. For adults, the daily intake requirement of magnesium is 4 µg/kg body weight(17). Magnesium is essential for energy metabolism, nerve signal transmission, muscle and heart contraction, and RNA and DNA production. The potassium values obtained (0.69-22.52 mg/100g) were consistent with the 10.64-20.37 mg/100ml reported by Hardisson *et al*.(16). Potassium supports healthy neuron and muscle function and helps maintain fluid balance, while also aiding in lowering blood pressure. Sodium plays a role in maintaining normal blood pressure, neuron and muscle health, and fluid balance(18). The ranges for sodium, zinc, and iron were 1.08-14.44 mg/100g, 1.14-25.14 mg/100g, and 0.74-1.67 mg/100g, respectively, aligning with literature values of 2.63-55.50 mg/100g, 0.53-4.24 mg/100g, and 1.68-5.48 mg/100g(16). Zinc is vital for the immune system, wound healing, cell growth and division, blood clotting, thyroid function, taste and smell, and DNA synthesis. It also supports normal growth and development during pregnancy, childhood, and adolescence(17). The daily requirements for zinc and iron are 65.5 μg/kg body weight/day and 25 mg/day, respectively(18). It is recommended that sodium intake not exceed 2300 mg/day for adults to avoid cardiovascular diseases and to prevent reduced absorption of calcium and potassium(19). A serving of 200 g of banana flour paste provides 6-20% of the daily iron requirement and 0.1-3% of the magnesium requirement, depending on the banana species, while other mineral contributions are negligible. Iron is crucial for hemoglobin production and is stored in muscles, bone marrow, liver, and spleen.

The observed peak viscosity values for banana flour (221.12-260.04 RVU) were lower than the range reported by Marta et al(20) which were 306.10-431.88 RVU. In contrast, the peak viscosity for plantain flour (257.79 RVU) was higher than the 271 RVU reported in the literature by the same authors. According to them, this variation could be attributed to different cultivars.The high final viscosity value of blue java banana suggests that when cooked, it may create a thicker paste compared to other samples. Final viscosity refers to the ability of starch to form a viscous paste after cooling. Generally, the firmer and springier the sample, the higher the final viscosity. Flour with a high setback viscosity has a strong capacity to retain water and expand when heated, potentially resulting in a moister and more delicate finished product. However, too high a setback viscosity can also lead to a sticky, gummy texture. Peak time measures the duration it takes for a heated mixture of wheat and water to reach its maximum viscosity, which is crucial for determining the pasting properties of flour. This measurement helps assess the flour's compatibility and predict the texture and structure of the end product. Peak time represents the cooking duration for the gelatinization of starch. Several changes occur in a heated starch-water system, including significant swelling, increased viscosity, translucency, solubility, and the disappearance of anisotropy(21,22). The observed pasting temperatures for banana and plantain flours (86.03-88.88°C) were higher than those reported in the literature (78.66-81.47°C)(20). A higher pasting temperature means the flour requires more time and energy to cook (gelatinize).

Paste (Amala) made with red banana was the most acceptable, followed closely by the one prepared from blue java banana.

CONCLUSION

This research showed that pastes (*amala*) produced from unripe banana species were acceptable to the consumers. The Red banana sample was the richest in protein and fibre, the minerals (K, Mg, Zn, Na and Fe) were significantly higher in Blue java, Cavendish and Red banana than in Plantain. In terms of general acceptability, pastes (*Amala*) from Red banana was the most preferred.

Availability of data and materials:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.:

Conflicting interests:

The authors declare that they have no Conflicting Interests

REFERENCES

1. FAO. (2013). Core production data. Food and Agricultural Organization of the United Nations, Rome. http://www.fao.org/faostat/en/#data/QC.
2. Faisant, N., Gallant, D. J., Bouchet, B. and Champ, M. (1995). Banana starch breakdown in the human small intestine studied by electron microscopy. European Journal of Clinical Nutrition, 49, 98–104.
3. Juarez-Garcıa, E., Agama-Acevedo, E., Sa´yago-Ayerdi, S. G., Rodrı´guez-Ambriz, S. L. and Bello-Pe´rez, L. A. (2006). Composition, digestibility and application in breamaking of banana Flour. Plant Foods for Human Nutrition, 61, 131–137. · DOI: https://doi.org/10.1007/s11130-006-0020-x.
4. Vergara-Valencia, N., Granados-Pereza, E., Agama-Acevedo, E., Tovar, J., Ruales, J. and Bello-Pe´rez, L. A. (2007). Fiber concentrate from mango fruit: Characterization, associated antioxidant capacity, and application as a bakery product ingredient. Lebensmittel-Wissenschaft and Technologies, 40, 722–729. https://doi.org/10.1016/j.lwt.2006.02.028Ge
5. Eleazu, C., Okafor, P. and Ahamefuna, I. (2010). Total antioxidant capacity, nutritional composition, and inhibitory activity of unripe plantain (Musa paradisiaca) on oxidative stress in alloxan-induced diabetic rabbits. Pakistan Journal of Nutrition, 9, 1052-1057. URL: http://pjbs.org/pjnonline/fin1811.pdf
6. Eleazu, C. O., Okafor, P. N., Amajor, J., Awa,

E., Ikpeama, A. I. and Eleazu, K. C. (2013). Chemical composition, antioxidant activity, functionalproperties and inhibitory action of unripe plantain(M. Paradisiacae) flour. Afr. J. Biotechnol.,10(74): 16937-16947. **DOI:10.5897/AJB10.1180**
7. Salome, K. K., Awofadeju, O. F. J. and Olapade, A. A. (2021). Chemical and Functional Properties of Blends Made from Unripe Plantain (MusaParadisiaca) and African Yam Bean (Sphenostylis Stenocarpa) Flours for Stiff Dough(Àmàlà) Preparation1. J. Appl. Sci. Environ. Manage.Vol. 25 (5) 741-749. DOI: https://dx.doi.org/10.4314/jasem.v25i5.8
8. Jimoh, K. and Olatidoye, O. (2009). Evaluation of physicochemical and rheological characteristics of soybean fortified yam flour. J. Appl. Biosci., 13, 703-706.
9. Awoyale, W., Maziya-Dixon, B., Sanni, L. O. and Shittu, T. A. (2010). Nutritional and sensory properties of amala supplemented with distiller's spent grain (DSG). Journal of Food, Agriculture & Environment, 8(3&4), 66-70.
10. Zakpaa, H. D., Mak-Mensah, E. E. and Adubofor, J. (2010) Production and characterization of flour produced from ripe 'apem' plantain (Musa sapientum L. var. paradisiacal; French horn) grown in Ghana. Journal of Agricultural Biotechnology and Sustainable Development, 2(6), 92-99.
11. AOAC. (2019). Official Methods of Analysis of the Association of Official Analytical Chemists,21st Edition. AOC International, Gaithersburg, MD, USA. 923.03, 923.05, 9662.09, 979.09
12. Shahanas, E., Seeja Thomachan Panjikkaran, Sharon, C.L., Aneena, E.R.,Suma, B. and Minimol, J.S. (2020). Physico Chemical Properties of Chocolates and itsVariability with Process Conditions. · The Indian Journal of Nutrition and Dietetics 57(1):73. DOI: 10.21048/ijnd.2020.57.1.24195
13. Adegunwa, M. O., Alamu, E. O. and Omitogun, L. A. (2011). Effect of processing on the nutritional contents of yam and cocoyam tubers. Journal of Applied Biosciences, 46, 3086-3092.
14. Wanita, Y. P., Indrasari, S. D. and Wiranti, E. W. (2021). The quality improvement of yam flour (*Dioscorea alata*) through the fermentation process. In IOP Conference Series: Earth and Environmental Science (Vol. 759, No. 1, p. 012031). IOP Publishing. DOI 10.1088/1755-1315/759/1/012031
15. Ajala, S. and Idowu, T. O. (2016). Investigation on the quality of Elubo at different drying temperatures. Toxicology.
16. Hardisson, A., Rubio, C., Baez, A., Martin, M., Alvarez, R. and Diaz,E. (2001). Mineral composition of the banana (Musa acuminata) from the island of Tenerife. Food Chemistry, 73(2), 153-161. DOI:10.1016/S0308-8146(00)00252-1.
17. Aquarobics, H. O., Olaofe, O. and Akintayo, E. T. (2011). Chemical composition, calcium, zinc and phytate interrelationships in Albizia lebbeck and Daniellia oliveri seeds. Oriental Journal of Chemistry, 27(1), 33.
18. FAO/WHO (2001).Human vitamin and mineral requirements. Report of a joint FAO/WHO expert consultation, Bangkok, Thailand.
19. Woodruff R. C, Zhao L, Ahuja J. K, et al. (2016). Top Food Category Contributors to Sodium and Potassium Intake — United States, 2015–2016. MMWR Morb Mortal Wkly Rep 2020;69:1064–1069. DOI: 10.15585/mmwr.mm6932a3.
20. Marta, H., Cahyana, Y., Djali, M., Arcot, J. and Tensiska, T. (2019). A comparative study on the physicochemical and pasting properties of starch and flour from different banana *(Musa spp.)* cultivars grownIndonesia. International Journal of Food Properties, 22(1), 1562–1575 Doi:10.1080/10942912.2019.1657447
21. Shimelis, E. A., Meaza, M. and Rakshit, S. (2006). Physico-chemical properties, pasting behavior, and functional characteristics of flours and starches from improved bean (Phaseolus vulgaris L.) varieties grown in East Africa. CIGR Ejournal 8:1–18 https://hdl.handle.net/1813/10533.
22. Ikegwu, O. J., Okechukwu, P. E. and Ekumankana, E. O. (2010). Physico-chemical and pasting characteristics of flour and starch from achi Brachystegia eurycoma seed. Journal of Food Technology, 8(2), 58-66. http://docsdrive.com/pdfs/medwelljournals/jftech/2010/58-66.pdf.