Evaluation of the Nutritional, Phytochemicals and Functional Properties of Flour Blends Produced from Unripe Plantain, Soybean and Ginger

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Authors' contributions

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ABSTRACT

This study was conducted to evaluate the nutritive value, phytochemicals and functional properties of flour blends from unripe plantain, soybean and ginger. Fresh samples of unripe plantain, soybean and ginger were dried and milled to produce five flour blends. Laboratory analyses of functional properties, phytochemicals and chemical proximate were determined according to standard procedures. Data generated were subjected to analysis of variance. The results showed that there were significant differences (P<0.05) among the samples. Sample showed higher carbohydrate content (84.21%) while the other flour blends had lower values with sample B (75.15%), C (68.71%), D (60.57%) and E (57.40%) in decreasing order. The protein content observed in the samples were; sample E (23.91%), D (22.53%), C (15.54%), B (11.81%) and sample A was the least (5.25%). The mineral analysis showed that flour blends B, C, D and E had higher values for all minerals determined except for sodium. The results obtained for functional properties of flour blends from sample B to E were higher in foaming capacity, solubility, water absorption and oil absorption capacity. The highest alkaloid content (6.43%) was observed in blend

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A and was followed by B (6.23%), C (5.99%), D (5.75%), and E (4.84mg/kg) in that decreasing order. From all indications, it was evidence that these flour blends sample had higher nutritional value, functional properties and lower amount of phytochemicals to cause any deleterious effects.

1. INTRODUCTION

There is increased advocacy on the consumption of functional foods by world humans' nutrition due to different health problems related with food consumption such as diabetes and coronary heart diseases [1]. Food professional/industries might face challenges of producing food products containing functional ingredients in order to meet the nutritional requirement of individuals with health challenges. The prospect of blending tubers, roots and plantain with cereals and legumes for the production of household food products is receiving considerable attention [2]. This might make the product to be nutritious, relatively cheap and affordable to the rural dwellers.

Plantain *(Musa paradisiacal)* is a staple crop in humid and sub-humid parts of Africa, Asia, Central and South America. It is usually eaten as an energy yielding food. Its hypoglycemic actions in diabetic animals have been reported [3]. Several foods consumption surveys in Nigeria identified plantain among the major starchy staples. An average plantain has about 220 calories and is a good source of potassium and dietary fiber. It is rich in carbohydrate, iron, vitamins and minerals. The nutritious food is ideal for diabetes, children and pregnant women. It can also be a good supplement for marasmus patients. Its regular consumption helps to cure anemia and maintain a healthy heart [2].

Soybean belongs to the family Fabaceae and the genus Glycine. Soybean contains 46% protein and 18% fats. Nigeria is one of the highest producers of soybean and nearly all the soybean production estimated at 30,000 tons is used as human food. Soybean is one of the most important oil and protein crops of the world. The protein content of soybean is about 2 times of other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk. Soybean has 3% lecithin, which is helpful in brain development. It is also rich in calcium, phosphorus and vitamins; A, B, C and D. It has been referred to as "the protein hope of the future" [4]. Moreover, isoflavones contained in soybean are effective cancer preventive agent for lowering risk of various cancers. Evidence also points to the beneficial effects of soy isoflavones in the prevention of cardiovascular disease [4].

Ginger *(Zingiber officinale)* is cultivated in the tropics for its edible rhizome. In a tropical Nigerian diet, ginger is one of the most common species that is used to add flavour to meals. Studies have also shown its hypoglycemic properties [5]. Ginger root or an underground stem (rhizome) known to contain gingerols (oleoresin) with several health benefits. It reduces the risk of colon cancer, obesity, diabetes, cardiovascular diseases, cold related diseases and arthritis [6].

Considering the health benefits of unripe plantain, soybean and ginger, their incorporation in the preparation of composite flour will enhance nutritional and health status of the consumers. Several studies have reported the use of plantain flour and ginger to manage Diabetes mellitus in Nigeria [5] but the possibility of combining them in a typical diet that included soybean is unknown. Hence, this study is aimed at evaluating the nutritional, functional properties and phytochemicals of flour blends produced from unripe plantain, soybean and ginger.

2. MATERIALS AND METHODS

2.1 Materials

Unripe plantain and ginger roots were bought from Jattu market in Auchi, Edo State Nigeria; defatted soy bean flour (Variety TGX 1448-2E) and other reagents were purchased from Benin City, Edo State, Nigeria.

2.1.1 Processing of plantain flour

Fresh unripe plantain was peeled, sliced using slicer and dried in an oven at 60°C for 48 hours. Dried sample was ground into powder (plantain flour).

2.1.2 Processing of soybeans to defatted flour

Soybean seeds were cleaned and sorted manually to remove dirt such as leaves and

stones. The cleaned soybean seeds were coarsely milled to separate the coat from the cotyledon. The dehulled seeds were milled to fine soybean flour using an attrition mill. The fine soybean flour was then defatted using cold extraction with n-hexane. The defatted flour was air-dried and the clumps broken into fine flour, then sieved through a mesh screen.

2.2 Processing of Ginger Powder

Fresh ginger roots were sorted and washed to remove soil and other foreign materials then sliced to thin layers and dried in an oven at 60^oC for 24 hours before milling to powder.

2.3 Formulation of Unripe Plantain, Soybeans and Ginger Flour Blends

Five samples were prepared from the combinations of unripe plantain, defatted soybean and ginger as blends mixed in different proportions using Nutri-survey linear programming software version 2007 to obtain the formulations;

A=100% unripe plantain
B=80% unripe plantain, 14% soybean, 6% ginger
C=70% unripe plantain, 26% soybean, 4%ginger
D=60% unripe plantain, 38% soybean, 2% ginger
E= 50% unripe plantain, 50% soybean

2.4 Methods of Analysis

The Atomic Absorption Spectrophotometer (AAS Model SP9) was used to analyze iron and calcium content of the flours, while the sodium and potassium contents of the flours were determined using flame photometer. The moisture content was determined in a hot-air at 105^oC 3 hours circulating oven (Galenkamp). Ash was determined by incineration (550^oC) of known weight of sample in a muffle furnace (Hot box oven, Gallencamy, UK, size 3). Crude fat was determined by the exhaustively extracting a known weight of sample in petroleum ether (boiling point 40-60^oC) using Tecatorsoxtec (Model 2043(20430001), 69 Slandegarupgade, DK-3400 Hilleroed, Denmark). Protein content (Nx6.25) was determined by the micro-kjeldahl method (Method No 978.04). Crude fiber was determined after digesting a known weight of fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide. Carbohydrate content

was determined by difference that is addition of all the percentages of moisture, fat, crude protein, ash and crude fiber and subtracting from 100%. This gave the amount of nitrogen free extract otherwise known as carbohydrate by the Association of official Analytical Chemist [7]. Bulk density, water and oil absorption capacities were determined using the methods reported by Arisa et al. [8]. Foaming capacity, solubility, swelling capacity and phytochemical screening of the samples were carried out.

2.5 Phytochemical Determination

Flavonoid was determined by the method of [9]: 10 g of the sample was extracted repeatedly with 100 mL of 80% aqueous methanol at room temperature. The whole solution was filtered through Whatman filter paper No 42. The filtrate was later transferred into a crucible and evaporated into dryness over a water bath and weighed to a constant weight.

Alkaloid was determined by the alkaline precipitation gravimetric method described by [10]. 5 g of the sample was weighed into 50 mL of 10% acetic acid solution in ethanol in a 250 mL beaker. The mixture was shaken and allowed to stand for 4 hours then filtered with Whatman No. 42 filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation using a steam bath. Alkaloid in the extract was 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 filtered paper and washed with 1% ammonia solution (NH_4OH), dried in the oven at 80^oC for 1 hour. It was later cooled in a desiccator and reweighed. By weight difference, the weight of alkaloid was determined and expressed as percentage of the sample analyzed, using the formula.

$$\% \text{ Alkaloid} = \frac{W_2-W_1}{W} \times \frac{100}{1}$$

Where:

W= weight of sample
W_1= weight of empty filter paper
W_2= weight of paper + alkaloid precipitate

Saponin was determined by the method of [11]. 20 g of sample was dispersed in 200 mL of 20% ethanol. The suspension was heated over a hot water bath for 4 h with continuous stirring at about 55^oC. The mixture was filtered and the

residue re-extracted with another 200 mL of 20% ethanol. The combined extracts were reduced to 40 mL over water bath at about 90^oC. The concentration was transferred into a 250 mL separating funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ethyl layer was discarded. The purification process was repeated. 60 mL of n-butane extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the sample were dried in the oven into a constant weight. The saponin content was calculated in percentage.

Tannin was determined using Follins Dennis spectrophotometric method according to [12]. 5 g of the sample was dispersed in 50 mL of distilled water and shaken. The mixture was allowed to stand for 30 min at room temperature and shaken every 10 min. at the end of the 30 min, the mixture was filtered through Whatman filter paper and the filtrate was used for the experiment. Two milliliters (2 mL) of the extract was measured into 50 mL volumetric flask. Similarly, 5 mL of standard tannic acid solution and 5 mL of distilled water were measured into separate flask to serve as standard and blank respectively. They were further diluted with 35 mL distilled water separately and 1 mL of Follin-Dennis reagent was added to each of the flask, followed by 2.5 mL of saturated sodium carbonate solution (NA_2CO_3). The content of each flask was then made up to 50 mL at room temperature. The absorbance of the developed colour was measured at 620 nm wavelength in spectrophotometer. Readings were taken with the reagent blank at zero.

2.6 Design and Data Analysis

Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations (P<0.05) among mean values obtained. The values used for each treatment were in triplicate. Where significant differences existed Duncan's multiple range test was applied to indicate where the differences occurred using Genstat statistical package 2005, 8TH edition (Genstat Procedure Library Release PL16). Where blend A=100% unripe plantain; B=80% unripe plantain, 14% soybean, 6% ginger; C=70% unripe plantain, 26% soybean, 4% ginger; D=60% unripe plantain, 38% soybean, 2% ginger and blend E=50% unripe plantain, 50% soybean.

3. RESULTS AND DISCUSSION

Table 1 showed the proximate composition of the formulated flour blends. There were significant differences (P<0.05) in the moisture content of the various flour blends. The moisture content of the 100% unripe plantain flour (sample A) was 5.27% while the other flour blends (sample B to E) showed gradual increase from 5.82 to 7.11% respectively. These results were within the moisture content (<10%) of flour reported by Agoyero et al. [13]. Moisture content of foods or processed products determines the shelf stability of products. Hence, the 100% unripe plantain flour is more stable compared to the other flour blends due to its lowest moisture content (5.27%). The protein content of these blends ranged from 5.25% -23.91%, this was higher than the substituted yam blends (11.10%-12.61%) which was compared with yam flours and wheat flours (1.29% and 10.71% respectively) by Oroniran et al. [14]. Sample E (50% unripe plantain and 50% soybean) contained the highest (23.91%) crude protein, followed by sample D (22.53%), C (15.54%), B (11.81%) and A (5.25%) in that decreasing order. The recommended daily allowance for protein in diabetic patients is 15-20% of the total calories [15]. The highest protein value recorded in sample E could be attributed to the highest inclusion of soybean (50%). The fat content ranged from 2.41%-3.94%; this was higher than the fat content of yam blends (1.3%-2.5%) [14]. The flour blends of sample B (2.57%), C (3.59%), D (3.84%) and E (3.94) contained higher fat content compare to sample A (2.41%) which had the least fat content as showed in Table 1. Sample A (84.21%) contained the highest carbohydrate content amongst the samples investigated while sample E (57.40%) unripe plantain and soybean in ratio 50:50 had the least. The recommended daily allowance for carbohydrate in diabetics is 50-70% of the total calories [15]. Crude fiber was significantly different (P<0.05) among the samples. Flour blend B (1.53%), C (2.38%), D (2.80%), and E (3.16%) had higher fiber content in increasing order compare to sample A (0.91%). However, these values were not in agreement with [13] who reported 10.43% and 10.11% for sundried and oven-dried flours respectively. Dietary fiber is important for human digestive health and regular bowel movement. It also helps to full the stomach for longer time; it can improve cholesterol and blood sugar levels and assist in preventing diseases such as diabetes, heart disease and bowel cancer.

Ash is the inorganic residue after water and organic matter have been removed by burning food sample. Ash content was significantly different (P<0.05) among the samples. The ash content of sample A (2.68%) had the lowest value, this was followed by sample B (3.14%), C (3.50%), D (3.30%) and the highest was observed in sample E (4.49%).

Table 2 showed the mineral content of the samples. Variation in mineral content tends to be high, owing to various degree of formulation of samples. Flour blends B, C, D, and E contained significant higher (P<0.05) quantities of mineral content compared to sample A where sodium (Na) was higher. From the results in Table 2, sample B (9.32 ppm), C (9.42 ppm), D (9.45 ppm) and A (7.05 ppm) contained higher amount of potassium than the sample E (1.10 ppm). Potassium is an important mineral in the body that regulates fluid balance, muscle contraction and nerve signals. High potassium may reduce blood pressure and water retention, protect against stroke and prevent osteoporosis and kidney stones while low dietary potassium (K) is associated with increased risk of incident diabetes [16]. Calcium content in the blends increased with increasing amount of soybean. There was higher amount of calcium in sample B (430.41 ppm), C (435.73 ppm), D (625.48ppm) and E (804.04 ppm) than sample A (236.11 ppm). Calcium plays an important role in muscle contraction, transmitting messages through the nerves and the release of hormones. Calcium is also important mineral in the formation of teeth and bones. Calcium is an important component of intracellular processes that occur within insulin responsive tissues like muscle and adipose tissues The highest sodium content was observed in sample A (75.66 ppm), followed by sample B (67.20 ppm), C (66.01 ppm), D (62.09 ppm), the least was observed in sample E (47.81 ppm) in decreasing order. Sodium is essential for life. It helps to control the body's fluid balance. It send nerve impulses and affects muscle function. The highest iron content was seen in sample E (141.49 ppm), this was followed by sample D (121.43 ppm), next was sample C (113.65 ppm), then sample B (92.90 ppm), the least iron was observed in sample A (28.65 ppm). Iron influences glucose metabolism, insulin action and it also interferes with insulin inhibition of glucose production by the liver [16].

The functional properties of the flour blends are showed in Table 3. There was significant difference (P<0.05) in the solubility of the blends. Solubility of flour of various blends increased with increasing level of soybean and decreasing level of unripe plantain flour inclusion. The highest solubility was observed in blend E (11.66%) this was followed by blend D (11.24%), C (10.47%), B (8.45%) and A (4.93%) in that decreasing order. It was observed that the foaming capacity and water absorption increased with increasing solubility value. The bulk density of the different flour blends ranged from 0.72 to 0.76 g/ml with sample A (0.76 g/ml) 100% unripe plantain flour having the highest value while sample E (0.72 g/ml) 50% unripe plantain and 50% soybean the lowest (Table 3). The higher the bulk density, the denser the flour, suggesting that 100% unripe plantain flour was heavier than the composites. Information on bulk density may be useful in packaging. The observation is closed to the findings of [17] who reported a bulk density of 0.46 g/cm^3 for unripe plantain flour. Oil absorption capacity ranged from 222.6% to 237.8% with samples A (222.6%), B (231.6%), C (236.0%), D (235.9%) and E (237.8%). The water absorption capacity also followed similar trend ranging from 237.1-299.6% with sample A having (237.1%), B (248.1%), C (282.0%), D (282.3%), the highest was observed in E (299.6%). The water holding capacity of flour blends increased with increase in protein content. This is in agreement with the report of [18] who observed that addition of soy flour to plantain flour confers high water binding capacity which in turn improves the reconstitution and textural abilities obtained from plantain flour. These suggest that increase in water absorption in the blends could be useful in bakery products such as bread, cakes, cookies that requires hydration to improve dough handling characteristics. Foaming capacity for the flour blends ranged from 2.04% to 8.16% from sample A to E respectively (Table 3). Foaming capacity increased progressively with increase in protein concentrates. The decrease in foam volume after 1hour was highest in sample A (2.04%), indicating that the foam volume was unstable when compared to sample B (4.09%), C (6.13%), D (6.14%) and E (8.16%). The formation of foam is essential in the preparation of several traditional cowpea-based food products in Nigeria [19]. The value of the swelling capacity was found to be highest for sample A (760.0%), followed by B (599%), C (553%), D (521%), the least was sample E (509%). The swelling capacities of the flours depend on the size of the particles, types of varieties and type of processing methods or unit operations.

5

Table 1. Proximate composition of unripe plantain, soybean and ginger flour blends

	Flour blends (%)					
Parameter	A	B	C	D	E	SEM
Moisture	5.27[e]	5.82[d]	6.29[c]	6.57[b]	7.11[a]	0.03
Ash	2.68[e]	3.14[d]	3.50[c]	3.70[b]	4.49[a]	0.01
Protein	5.25[e]	11.81[d]	15.54[c]	22.53[b]	23.91[a]	0.04
Fat	2.41[e]	2.57[d]	3.59[c]	3.84[b]	3.94[a]	0.02
Fiber	0.91[e]	1.53[d]	2.38[c]	2.80[b]	3.16[a]	0.01
Carbohydrate	84.21[a]	75.15[b]	68.71[c]	60.57[d]	57.40[c]	0.04

Means with same superscript along the row are not significantly differently (P>0.05).
SEM=Standard error of mean

Table 2. Mineral content of unripe plantain, soybean and ginger flour blends

	Flour blends (ppm)					
Parameter	A	B	C	D	E	SEM
Calcium	236.11[e]	430.41[d]	435.73[c]	625.48[b]	804.04[a]	0.22
Sodium	75.66[a]	67.20[b]	66.01[c]	62.09[d]	47.81[e]	0.002
Potassium	7.05[d]	9.32[c]	9.42[b]	9.45[a]	1.10[e]	0.02
Iron	28.65[e]	92.90[d]	113.65[c]	121.43[b]	141.49[a]	0.02

Means with same superscript along the row are not significantly differently (P>0.05).
SEM=Standard error of mean

Table 3. Functional properties of unripe plantain, soybean and ginger flour blends

	Flour blends					
Parameter	A	B	C	D	E	SEM
Solubility (%)	4.93[e]	8.45[d]	10.47[c]	11.24[b]	11.66[a]	0.07
Foaming capacity (%)	2.04[d]	4.09[c]	6.13[b]	6.14[b]	8.16[a]	0.01
Swelling capacity (%)	760[a]	599[ab]	553[b]	521[b]	509[b]	42.6
Bulk density (g/ml)	0.76[a]	0.74[b]	0.73[bc]	0.73[c]	0.72[c]	0.003
Water absorption (%)	237.1[d]	248.1[c]	282[b]	282.3[b]	299.6[a]	2.40
Oil absorption (%)	222.6[c]	231.6[b]	236[a]	235.9[a]	237.8[a]	0.85

Means with same superscript along the row are not significantly differently (P>0.05).
SEM=Standard error of mean

3.1 Phytochemical Properties

Table 4 shows the phytochemical compositions of the flour blends. The lowest tannin content (0.27 mg/kg) was observed in food blend A and was followed by blend B (0.55). Blends C, D and E had the same tannin content (0.61 mg/kg). The highest alkaloid content (6.43%) was observed in blend A and was followed by B (6.23%), C (5.99%), D (5.75%), and E (4.84 mg/kg) in that decreasing order. Blends B and C had the same flavonoid content (0.42 mg/kg) which was higher than the other blends. The lowest flavonoid content (0.11mg/kg) was observed in blend A; this was followed by E (0.31 mg/kg) and D (0.35 mg/kg). Blend A (0.16) had the lowest saponin content and was followed by B (2.39 mg/kg), C (3.99 mg/kg), D (4.22 mg/kg), and E (6.33 mg/kg)

in increasing order. Saponins are known to possess both beneficial (cholesterol lowering) and deleterious (cytotoxic permeabilization of the intestine and paralysis of the sensory system) properties [20]. Flavonoids, alkaloids and tannins are polyphenolic compounds with antioxidant properties. In addition, phenolic compounds existing in plants are also responsible for their contribution to colour, sensory and antioxidant properties of food [21]. The low phytochemical values (Table 4) recorded in this study are significantly lower than (p<0.05) the results of [22] who recorded significant values (saponin 1.827, flavonoid 0.981 and tannin 1.577) in unripe plantain flour. However, he further reported that the levels of saponin in the flour are quite too low to cause any deleterious effects.

Table 4. Phytochemical properties of formulated food blends

Blends	Phytochemicals			
	Tannin (mg/100 g)	Alkaloids (%)	Flavonoids (mg/100 g)	Saponin
A	0.27[c]	6.43[a]	0.11[d]	0.16[d]
B	0.55[b]	6.23[b]	0.42[a]	2.39[c]
C	0.61[a]	5.99[c]	0.42[a]	3.99[b]
D	0.61[a]	5.75[d]	0.35[b]	4.22[b]
E	0.61[a]	4.84[e]	0.31[c]	6.33[a]
SEM	0.008	0.014	0.005	0.008

Means with the same letters down the column are not significantly different (p>0.05)
SEM= Standard error of mean

4. CONCLUSION

Combination of unripe plantain, soybean and ginger flour blends in adequate proportion has high nutritional value such as protein, ash, crude fiber, minerals especially potassium and calcium, low fat and low phytochemicals. Dietary fiber enhances the transit time through the bowels, facilitate bowel's movement thus, reducing the risk of colon cancer. Calcium plays an important role in muscle contraction, transmitting messages through the nerves and the release of hormones. Potassium is an important mineral in the body that regulates fluid balance, muscle contraction and nerve signals. High potassium may reduce blood pressure and water retention, protect against stroke and prevent osteoporosis and kidney stones while low dietary potassium (K) is associated with increased risk of incident diabetes. Besides, this study revealed that unripe plantain, soybean and ginger flour blends have good functional properties such as the water absorption capacity. It was observed that the foaming capacity and water absorption capacity increased with increasing solubility value. The high water absorption capacity could be ascribed to the presence of soy flour in the blends. The increase in water absorption capacity in the blends could be useful in bakery products such as bread, cakes, cookies that requires hydration to improve dough handling characteristics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. WHO/FAO. Diet, nutrition and prevention of chronic diseases. Report of WHO/FAO Exper Consultation. World Health Organisation Technical Report, series 916. 2003, WHO Genera.

2. Ibeam V, Onyechi U, Ani P, and Ohia C. Composition and sensory properties of plantain cake. African Journal of Food Science. 2016;10(2):25-32.

3. Ojewole JA, Adewunmi CO. Hypoglycemic effect of methanolic extract of Musa paradisiacal green fruits in normal and diabetic mice. Method Find. Exp. Clin. Pharm. 2003;25:453-456.

4. Ndife J, Abdulraheem LO, Zakari UM. Evaluation of the nutritional and sensory quality of Functional breads produced from whole wheat and soybean flour blends. African Journal of Food Science. 2011; 5(18):466-472.

5. Iroaganachi M, Eleazu CO, Okafor PN, and Nwaohu N. Effect of unripe plantain and ginger on the blood sugar, body weight and feed intake of streptozotocin induced diabetic rats. The Open Biochemistry Journal. 2015;9:1-6.

6. Barley-Shaw YA, William LA, Junior G, Green CE, Hibbert SL, Salmon CN, and Smith AM. Changes in the content of Oleoresin and Ppungent Bioactive. Principles of Jamaican Ginger during maturation. J. of Agric. Food Chemistry. 2008;56(4): 5564-5571.

7. A.O.A.C. 19th Ed. Association of Official Analytical Chemist, international, Gaithersbury, MD, USA; 2012.

8. Arisa NN, Adelekan AO, Alamu AE, Ogunfowora EJ. The Effect of pretreatment of plantain (*Musa paradisiaca*) flour on pasting and sensory characteristics of biscuit. Int. Journal of Food and Nutri. Sci. 2013;2(1):10-23.

9. Boham BA, Kocipal-Abyazan R. Flavonoids and condensed tannin from leaves of Hawaiian *Vaccinium vaticulatum* and *V. calycinium*. Pacific Science. 1994; 48:458-463.

10. Harbone JB, Phytochemical methods; A guide to modern techniques of plant

analysis. Chaman and hall ltd, London, UK. 1973;20-28.

11. Nahapetian A, Bassiri A. Changes in concentration and interrelationship of phytate, P, Mg. Cu, Zn in wheat during maturation. Journal of Agricultural and Food Chemistry. 1974;32:1179-1182.

12. Pearson D. Chemical analysis of food. 7th Edition, Church-hill Livingston, Edinburgh, UK. 1976;10-15.

13. Agoyero BO, Akpiroroh OO, Osaweren OR, Owabo CN. The effect of various drying Methods on the nutritional composition of *Musa paradisica, Discorea rotundata* and *Colocasia esculenta*. Asian J. Biochemistry. 2011;6:458-464.

14. Oroniran OO, Adegoke GO, Otegbayo BO. Chemical composition and acceptability of yam flour supplemented with whole wheat and soy flour. Nigerian Journal of Nutritional Sciences. 2014;35(2).

15. Vansunder V. Fundamental of biochemistry. 2nd Edition. 2006;110-214.

16. Chatterjir R, Colangelo LA, Yeh HC, Anderson CA, Daviglus ML, Liu K, and Brancati FL. Potassium intake and risk of incident type 2 diabetes mellitus, CARDIA. 2012:55(5):1295-1303.

17. Abioye VF, Ade-Omowaye BIO, Babatunde GO, Adesigbin MK. Chemical physicochemical and Sensory properties of Soy-plantain flour. African J. of Food Sci. 2011;5(4):176-180.

18. Adebowale YA, Adeyemi IA, Oshodi AA. Functional and physicochemical properties of flour of six *Mucuna* sp. African J. of Biotechnology. 2008;4(12): 1461-1468.

19. Mcwatter KH. Functionality of cowpea meal and flour in selected foods. In cowpea research production and utilization. SR, Singh and KO, Rachie (Eds.). Chockester John Willey and Sons. 1985;361-366.

20. Price KR, Johnson IT, Fenwic CR. The chemical and biological significance ofsaponins in food and feeding stuff. Unpublished Crit. Rev. Food Sci. Nutr. 1987;26:27-135.

21. Robbins RJ. Phenolic acids in foods. An overview of analytical methodology. J. Agric. Food Chem. 2003;51:2886-2887.

22. Eleazu CO, Okafor PN, Amajor J, Awa E, Ikpeama AI and Eleazu KC.Chemical Composition, antioxidant activity, functional properties and inhibitory action of unripe plantain (*M. paradisiacae*) flour. African Journal of Biotechnology. 2011;10(74): 16948-16952.