

*Full Length Research Paper*

# Nutrient composition and contribution of plantain (*Musa paradisiacea*) products to dietary diversity of Nigerian consumers

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Some plantain (*Musa paradisiacea*) products, which serve as dietary staple in Nigeria were studied for their nutrient composition and contribution to dietary diversification of consumers. Unripe plantain was purchased from Oje market in Ibadan, Nigeria. Proximate, mineral and vitamin composition of raw, sundried, fermented, boiled and roasted samples were determined using standard methods of analyses of AOAC, atomic absorption spectrophotometric and spectrophotometric methods respectively. The results of analyses revealed that unripe plantain contained 59.4 g moisture, 7.7 g crude protein, 1.5 g ash, 1.4 g crude fibre, 24.4 g carbohydrates, 80 mg sodium, 120 mg potassium, 66.6 mg calcium, 275 mg magnesium, 195 mg phosphorus, 2.53 mg iron, 3.7 mg zinc, and yielded 128.6 kcal of energy/100 g sample. Sun drying, fermentation, boiling and roasting significantly improved the crude lipid, ash, crude fibre, carbohydrate, sodium, potassium, calcium, magnesium, and phosphorus contents of the products ( $p < 0.05$ ). The low sodium content of the products makes them suitable for the hypertensive, and the low carbohydrate content coupled with relatively high energy make them suitable for consumption by the diabetics. 100 g of plantain products can contribute between 6.3 to 15.3% energy, 5.9 to 30.2% protein, 7.8 to 16% calcium, 9.2 to 23.3% iron, and 28.5 to 33.7% zinc to percent Recommended Dietary Allowances (%RDAs) of consumers.

**Key words:** Nutrient composition, nutrient contribution, plantain, dietary diversity.

## INTRODUCTION

Plantain and banana (*musa spp*) are major food crops in the humid and sub-humid parts of Africa and a major source of energy for millions of people in these regions (Asiedu, 1989). They are perennial crops that grow well in a wide range of environments (Nelson et al., 2006), and belong to the family of Musaceae with the genus *Musa* and have been crops of extraordinary significance to human societies. Presently, they rank as the fourth most important food crop in the world after rice, wheat and maize; and are used as food, beverages, fermentable sugars, medicines, flavourings and cooked foods (Nelson et al., 2006; Phillip et al., 2009).

Plantain plant consists of long, overlapping leafstalks and bears a stem which is 1.22 to 6.10 m high (Oladiji et al., 2010) and produces bunches with fewer but bigger fingers than banana, and are used locally in various forms by humans. They are often regarded as the "cooking bananas". The total production of plantains in 1988 was 24.0 million metric tonnes (Food and Agriculture Organization of the United Nations (FAO, 1988)), and in Nigeria, plantain production is estimated at about 2.4 million metric tonnes mostly obtained from the Southern state (Folayan and Bifarin, 2011). This accounts for its wide use in diverse ways alongside other foods as staple in Nigeria. Plantain tends to be firmer and lower in sugar content than dessert bananas. Bananas are most often eaten raw, while plantain usually required cooking or other processing, and are used either when

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green, under-ripe or over-ripe (Oke et al., 1998).

Half-ripe plantain is usually processed into plantain flour by slicing the plantain and sun drying for some days (Ngalani, 1989) and cooked into sticky paste delicacy “*Amala ogede*” (Yoruba), and “*Ebue*” (Ogonis) served with vegetable soup. Half-ripe plantain is also boiled, fried, processed into chips (Onyejebu and Olorunda, 1995), or boiled and pounded to plantain pastry and eaten with soups, sauce or vegetables (Tchango et al., 1999).

Ripe plantain flour has been used in making bread, biscuits and instant flour (Ngalani and Crouzet, 1995). The nutritional qualities and sensory attributes of wheat bread substituted with 15% plantain flour were comparable to that of whole wheat bread; hence, its adoption was recommended in bread making processes (Olaoye et al., 2006). The *Soyamusa*, a baby food from plantain flour (60%) was made and used in Nigeria (Ogazi et al., 1991; Idachaba, 1995; Ogazi, 1996).

In Nigeria, as one of the major staple foods, plantain is processed into various products such as ‘*elubo*’ (dried half-ripe plantain flour), ‘*dodo*’ (fried sliced ripe plantain pulp), chips (fried half-ripe pulp) (Akinwumi, 1999); and in addition to yam, it can be pounded to a sticky paste eaten with soup. It can also be processed to food/foodstuffs such as breakfast cereals, baby complementary foods (Folayan and Bifarin, 2011). The International Institute for Tropical Agriculture (IITA, (2005) reported that post-harvest loss of plantain is one of the major threats to the availability of the fruit that is a staple to many Nigerians. Ihekoronye and Ngoddy (1985) reported that fermentation may impart new colour, flavour, taste, and texture to food products, as well as enhancing the nutritive value and extending the shelf-life of the fermented products.

The current trend in nutrition in meeting consumers’ daily dietary needs is promotion of dietary diversification through locally available foods. However, little is known about the nutrient composition and nutrient retention of processed plantain products. It is therefore the objective of this study to provide information on the nutrient composition and potential contribution of dried, fermented, boiled and roasted plantain to dietary diversity of Nigerian consumers.

## MATERIALS AND METHODS

### Sample collection and preparation

Representative sample of matured, half-ripe plantain fruit was purchased from Oje market in Ibadan. The fruit was divided into two parts and treated as follows to obtain composite samples of plantain products. One part was peeled and sliced into about 5 mm diameter. The slices were then thoroughly mixed together and divided into three portions. One portion was labelled as raw sample (sample 1), another portion was sun-dried for four days and labelled as sample 2 (Ngalani, 1989), while the third portion was fermented anaerobically by soaking in distilled water for 48 h and labelled as sample 3. The fermented sample was drained after 48 h and

sundried for four days.

The second part was divided into two portions and processed into boiled plantain by cutting each finger of unpeeled fruit into three pieces and boiled with distilled water at 100°C for 10 min. The boiled sample was later oven-dried and labelled as sample 4, while the second portion was peeled as whole finger of plantain and roasted. The roasted plantain (*Boli*) was labelled as sample 5. All the dried five samples were milled / blended and analysed for their nutrient composition.

### Proximate composition

Moisture content of the samples was determined by air oven method (Gallenkamp, Model OV - 440, England) at 105°C. The crude protein of the samples was determined using micro-Kjeldahl method by digesting 5 g of the sample with conc. H<sub>2</sub>SO<sub>4</sub> and Kjeldahl catalyst in Kjeldahl flask for 3 h. The digest was made up to 100 ml and 5ml portion was then pipetted to Kjeldahl apparatus and 5 ml of 40% (w/v) NaOH solution was added. The mixture was steam distilled, and the liberated ammonia was collected in 10 ml of 2% boric acid, and titrated against 0.01 M HCl solution. The amount of crude protein was then calculated by multiplying percentage nitrogen in the digest by 6.25. Crude lipid was determined by weighing 5 g of dried sample into fat free extraction thimble and plugging lightly with cotton wool. The thimble was placed in the Soxhlet extractor fitted up with reflux condenser. The dried sample (at 60°C) was then extracted with petroleum ether and the crude lipid estimated as g/100 g dry weight of sample, and then converted to g/100 g fresh sample weight. The ash content was determined by weighing 5g of sample in triplicate and heated in a muffle furnace at 550°C for 4 h, cooled to about 100°C in the furnace and then transferred into a dessicator to cool to room temperature, weighed, and ash calculated as g/100 g original fresh sample. Crude fibre was determined using the method of Saura-Calixto et al. (1983). The carbohydrate content was obtained by difference. Gross energy of the samples was determined using ballistic bomb calorimeter (Manufacturer: Cal 2k – Eco, TUV Rheinland Quality Services (Pty) Limited, South Africa). All determinations were carried out in triplicates.

### Mineral analysis

Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer/spectronic20 (Bonire et al., 1990). Phosphorus was determined by Vanado-molybdate colorimetric method (Ologhobo and Fetuga, 1983). Calcium, magnesium, iron, zinc, manganese, and copper were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk United Kingdom (UK)) (Essien et al., 1992) and their absorption compared with absorption of standards of these minerals. Chi square test was performed on the results obtained with the level of significance set at  $p < 0.05$ .

## RESULTS

In Table 1, there was no significant difference between the moisture content of the sun-dried and fermented samples, likewise that of raw and boiled sample ( $p > 0.05$ ), though the value for boiled sample was slightly higher than that of the raw sample. There was a significant reduction in moisture content of roasted plantain

**Table 1.** Proximate composition of raw, sundried, fermented, boiled, and roasted plantain (g/100 g)\*.

Sample	Raw	Sundried	Fermented	Boiled	Roasted plantain
Moisture	59.4 ± 0.02	11.1 ± 0.03	11.2 ± 0.02	62.6 ± 0.03	47.3 ± 1.10
Crude Protein	7.7 ± 0.13	16.9 ± 0.12	3.4 ± 0.16	7.5 ± 0.09	3.3 ± 0.10
Crude Lipid	1.5 ± 0.02	3.9 ± 0.03	1.7 ± 0.01	3.8 ± 0.02	1.0 ± 0.02
Ash	1.4 ± 0.02	1.5 ± 0.01	0.8 ± 0.02	1.3 ± 0.02	2.4 ± 0.03
Crude Fibre	1.4 ± 0.02	3.8 ± 0.03	2.5 ± 0.02	1.5 ± 0.01	1.3 ± 0.02
**Carbohydrates	24.4 ± 0.19	60.2 ± 0.11	78.5 ± 0.15	18.8 ± 0.11	44.8 ± 1.19
Gross Energy (kcal/)	148.6 ± 0.14	350.5 ± 0.28	350.9 ± 0.14	144.4 ± 0.22	169.0 ± 1.00

\*n = mean value of three determinations; \*\*found by difference.

compared with the raw and boiled samples ( $p < 0.05$ ). Crude protein of sun-dried sample was significantly higher than that of raw, fermented, boiled and roasted samples ( $p < 0.05$ ). There was no significant difference in crude protein content of raw and boiled samples, but their values were significantly higher than that of fermented and roasted samples.

There was no significant difference in crude lipid content of sun-dried and boiled samples, but their values were significantly higher than that of raw, fermented and roasted samples ( $p < 0.05$ ). The crude fibre content of the sun-dried sample was significantly higher than that of other three samples ( $p < 0.05$ ). The boiled sample was slightly higher in crude fibre value compared with the raw and roasted samples, but the difference was not statistically significant ( $p > 0.05$ ). The carbohydrate content of fermented sample was significantly higher than that of other samples ( $p < 0.05$ ).

Sundried sample was significantly higher in mineral content than the rest of the samples, and fermentation, boiling and roasting resulted in significant reduction in almost all the minerals compared with the raw sample ( $p < 0.05$ ).

## DISCUSSION

The result of proximate composition of raw and processed plantain samples (Table 1) is in agreement with the one in literature (Murray, 2005; Gbolagade et al., 2011). However, the value obtained for crude protein, crude lipid and ash of the fresh plantain sample in this study was significantly higher than that reported by Ogazi (1996) while the carbohydrate content was significantly lower (1.2, 0.2 to 0.5, 0.8, and 35% respectively). This observed difference in nutrient composition might be due to species and geographic variations. The moisture content of sundried and fermented samples was very low, and this was suggestive of their long shelf-life and keeping quality. However, their moisture content was slightly higher than that of plantain-soy flour mix ( $10.65 \pm 0.03$ ) (Abioye et al., 2006).

The protein content of raw sample flour was low. Low

protein content is characteristic of plant foods especially fruits (Kuhnlein, 1989; Ishola et al., 1990). Drying of plantain resulted in significant increase in protein content (Sample 2). This was believed to be due to significant reduction in moisture content of this sample. Fermentation resulted in significant reduction in crude protein content of the fermented sample (Sample 3). This might have resulted from utilisation of part of the protein in meeting the fermenting enzymes' nutrient needs, or in the alternative, the plantain protein may be water soluble, thereby leaching into fermenting broth. However, there was an insignificant loss in crude protein of boiled plantain sample (Sample 4) compared with the raw (Sample 1). This insignificant reduction in crude protein content of the boiled sample supported the utilisation of the protein of sample 3 for nutrient needs by the fermenting microbes. Roasting of plantain resulted in highly significant reduction in protein content of the plantain ( $p < 0.05$ ). This was suggestive of the destruction of the protein due to application of heat, as high temperature results in protein denaturation and destruction (Ihekoronye and Ngoddi, 1985).

The crude lipid content of the raw sample was significantly lower than that of processed products except the roasted sample ( $p < 0.05$ ). This was an indication that processing improved significantly the crude lipid content of processed flour, with sundried sample (Sample 2) having the highest value, closely followed by the boiled sample. This observed increase in crude lipid content might be due to effect of application of heat during processing of samples 2 and 4, while in fermented sample no heat was applied. Part of the crude lipid might have burnt off during roasting of the plantain, hence the observed reduction in value.

Drying, boiling and roasting brought significant improvement in ash and crude fibre content of samples 2, 4, and 5. Fermentation resulted in reduction in the ash value but brought a slight increase in crude fibre content (sample 3) compared with the raw (sample 1). The amount of crude fibre in the flour samples may influence the digestibility of menu or diets prepared from the products, and may also help to maintain the normal internal distention of the intestinal tract and thus aid

**Table 2.** Mineral composition of Raw, Sundried, Fermented, Boiled, and Roasted plantain (mg/100g Edible portion)\*.

Sample	Raw	Sundried	Fermented	Boiled	Roasted plantain
Sodium	200.0 ± 1.41	245.0 ± 21.21	85.5 ± 2.12	195.0 ± 21.21	55.7 ± 1.15
Potassium	370.0 ± 14.41	380.0 ± 21.21	160.0 ± 14.14	365.0 ± 14.14	270.0 ± 1.00
Calcium	126.5 ± 2.12	140.0 ± 3.50	77.5 ± 2.12	93.0 ± 2.83	160.0 ± 10.00
Magnesium	375.0 ± 21.21	405.0 ± 15.36	195.2 ± 12.21	340.0 ± 14.14	350.0 ± 13.61
Iron	2.53 ± 0.03	3.50 ± 0.02	1.38 ± 0.02	2.45 ± 0.04	3.48 ± 0.01
Phosphorus	220.0 ± 21.21	225.0 ± 17.43	165.0 ± 11.21	190.0 ± 14.14	217.0 ± 11.16
Zinc	3.74 ± 0.02	3.66 ± 0.02	3.13 ± 0.01	3.60 ± 0.02	3.70 ± 0.02
Manganese	2.99 ± 0.05	2.74 ± 0.03	2.47 ± 0.02	2.65 ± 0.03	2.80 ± 0.02
Copper	1.66 ± 0.04	1.74 ± 0.02	1.47 ± 0.02	2.20 ± 0.02	1.60 ± 0.01

\*n = mean value of three determinations.

**Table 3.** Contribution of plantain products to % Recommended Dietary Allowances (RDAs)\*.

Sample	Energy		Protein		Calcium		Iron		Zinc	
	(2300)	%RDA	(56 g)	%RDA	(1000 mg)	%RDA	(15 mg)	%RDA	(11 mg)	%RDA
Sundried	350.5	15.2	16.9	30.2	140.0	14.0	3.50	23.3	3.66	33.3
Fermented	350.9	15.3	3.4	6.1	77.5	7.8	1.38	9.2	3.13	28.5
Boiled	144.4	6.3	7.5	13.4	93.0	9.3	2.45	16.3	3.60	32.7
Roasted plantain	169.0	7.3	3.4	5.9	160.0	16.0	3.48	23.2	3.70	33.7

\*Source: Wardlaw (1999).

peristaltic movements (Edem et al., 1984).

The carbohydrate content of the fermented and sundried flour samples were within the values reported by Abioye et al. (2006). Sun drying, fermentation and roasting brought a highly significant increase in carbohydrate content of the samples, while boiling resulted in reduction in carbohydrate content ( $p < 0.05$ ). The reduction in value of carbohydrate (Sample 4) was believed to be due to additional boiling water absorbed by the sample, as well as loss through leaching of soluble carbohydrates into the boiling water. Processing has been reported to improve carbohydrate availability in a more digestible form (Paradez-Lopez and Harry, 1989), hence, this explained the significant increase observed in the carbohydrate content of samples 2, 3 and 5.

The gross energy content of boiled sample was closely related to that of raw sample while the sundried, fermented and roasted samples were significantly higher ( $p < 0.05$ ), with sundried and fermented samples doubling the energy content of raw and boiled samples.

Raw plantain was rich in potassium, calcium, magnesium and phosphorus, moderate in zinc and manganese but very low in iron (Table 2). This fact was in support of the findings of Murray, (2005). Fermentation led to significant loss in all the minerals except sodium. This was believed to have resulted from leaching of these minerals into fermenting broth due to the length of time of fermentation (48 hours), because extent of soaking in water had been reported to reduce mineral content of

processed foods (Adepoju et al., 2010).

Boiling of plantain resulted in significant reduction in its calcium, magnesium, phosphorus, iron, zinc and manganese content ( $p < 0.05$ ), while the reduction in sodium and potassium were not significant ( $p > 0.05$ ). However, there was a significant increase in copper content of boiled sample compared with the other three samples. Roasting resulted in significant reduction in value of most of the minerals except iron, zinc and copper. The low sodium content of the products makes them suitable for the hypertensive, and the low carbohydrate content coupled with relatively high energy make them suitable for consumption by the diabetics. 100g portion of plantain products can contribute between 6.3 to 15.3% energy, 5.9 to 30.2% protein, 7.8 to 16% calcium, 9.2 to 23.3% iron, and 28.5 to 33.7% zinc to percent Recommended Dietary Allowances (%RDAs) of consumers (Table 3).

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