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Nutritional composition of processed and unprocessed samples of unripe plantain (*Musa × paradisiaca*)

Osanyinlusi Remi*
Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria
Correspondence Author: Osanyinlusi Remi
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Abstract
People usually think food processing bring about reduction in food nutrients as well as the quantity because few quantities must have been lost or wasted during processing, many said food processing affect the taste and color of the food when compared to its whole form. Meanwhile, food processing which also includes its preparation makes food last longer than when in its whole form (increases its shelf life), although its positive effects are numerous but its negative effects cannot be overlooked as it is agreed on that it affect the nutritional quality of food such as loses of some essential vitamins and minerals. In order to investigate this, three different methods (sun dry, oven dry, air dry) were considered to process plantain from a single source and it was compared to a fresh sample of the plantain from the same source. Proximate analysis, phytochemical screening, mineral, and organic matter and dry matter were carried out according to AOAC methods of analysis. The results showed that the unripe plantains pulp (fresh) contained 58.783% moisture, which is way higher than others. The ash 2.00%, fat 1.894%, crude protein 7.964%, are higher in fresh pulp sample compared to others whereas the organic matter, dry matter and the carbohydrate values are smaller compared to SPF, 0PF and APF. The sodium 0.154, Calcium 0.312, iron 0.921 are very high in the fresh sample than SPF, 0PF and APF. Glycoside, Saponin, tannins, alkaloids phlobatannins, terpenoids, flavonoids, phenols, and steroids were not detected in all the samples. However, the fresh sample has the highest moisture content which implies that there is going to be an increase in the rate of microbial growth which can spoil it and decrease its shelf life. Oven drying in the other hand gave the lowest moisture value in the flour samples, this suggests its ability to prevent microbial growth and decay in dried sample, hence prolonging storage life.

Keywords: proximate analysis, phytochemicals, fresh plantain sample, minerals, plantain flour

Introduction

Plantain (*Musa* × *paradisiaca*) is nurtured in the tropics and is an important staple food is sub–Saharan African. About 63 million tons of the crop are produced annually, of which as much as 90% is consumed locally in the producing countries allowing only a meager 10% for foreign financial earning through exportation (Awodoyin, 2003) [10], (Baiyeri *et al*., 2011) [12]. This is the largest attributed to poor storage condition of the crop, worsened by poor or lack of storage facilities and processing technology. Certain times, processed foods are not appreciated among the populace due to textural difference arising from the processing (Yarkwan 2004) [13].

Plantain falls under banana and it is a monocotyledonous perennial and important crop in the tropical and sub-tropical region of the world (Baiyeri *et al*. 2011) [12]. In Nigeria, Cameroon, cote d vore and other plantain producing countries in Africa, the entire pulp of the fruit plantain either unripe or half ripe are roasted and are usually eaten with avocado, roasted fish or meat, and sometimes in combination with hot stew. In Nigeria as well as other West African countries, the unripe plantain is traditionally made into flour (Ukhum and Ukpebor 1991) [41].

Plantain (*Musa Parasidiaca*) is one of the important staple food crops consumed in tropics behind rice, wheat and maize and are obtainable in about 120-130 tropical countries in the world (Kawangolo 2013). It is an essential food crop in sub-Sahara Africa that serious as source of nutrient and household income for many people around the world (Kawongolo) 2013). The aggregated world production is put at over 76 million meter tons (Olumba 2014) [35]. Out of which over 12 million metric tons are harvested yearly in Africa (Fakayode *et al*; 2011) [22] sizeable ton of plantains are harvested in Nigeria annually and Nigeria is the biggest producer of plantains in west Africa with an estimated/production of about 2.7 million metric tons, majority of which are produced and harvested from the southern part of the country (FAO 2009) [24] In spite of large tons of plantains harvested yearly in Nigeria (Olorunda and Adesola (1997) [34] reported that over 50% of plaintain harvested are lost due to unavailability of appropriate storage facilities to prevent post-harvest losses. These large production and post-harvest losses necessitate the need to develop new and suitable technologies for processing and preservation of plaintain flour for time to come. Usually harvested at matured but unripe stage, plaintain undergo rapid respiration after harvest, making it a short-lived agricultural product that requires urgent attention immediately after harvest, plaintain may therefore be processed into flour when it is matured but not ripe. Sun drying happens to be the most common method among citizens of Nigeria used in processing plantains into flour. However, there are some problems associated with sun drying such as slowness of the process uncertainty of the weather and unstable temperature which so many times has led to uneven drying (Arinola *et al*; 2016) [8]. Falade (2009) reported that sun drying is one of the best methods in terms of

cost management to preserve plaintain flour in other to have plaintain product with trusted shelf life. Sun drying is a suitable and affordable means for straining water from plaintain which add value to plaintain and this result in production of product having good shelf life (Demire and Turban 2003) [18].

Drying is one of the best methods employed in the processing and preservation of agricultural products and many researches have pointed to the drying of different agricultural products to confirms its suitability as per the shelf life. It is basically done to reduce moisture below level required for microbial and enzymatic growth (Doymaz, 2007). According to Arinola *et al*; (2016) [8], different drying method can be used for drying plaintain fruits. Microwave oven, air, sun, and freeze drying have been put to practice to dry plaintain (Emperatiz *et al.,* 2008) [19].

Drying, which could be sun drying, oven drying or air drying, is a common and effective method used in processing and preserving plantains. The unripe fruit is first peeled, sliced, dried and ground into fine powder (called Elubo-Ogede in Yoruba). Generally drying in the open air exposes such product to dirt, insect, bacteria infestation and the deposition of fungal spores, and a varying degree of other environmental toxicants, depending on the site/location of drying. Thus the need for a clean, hygienic, effective drying method is crucial new methods of drying include oven and solar drying both of which uses heat to remove the moisture content in the food to the barest minimum, by evaporation, the above listed modern method of drying are used in drying plant material at a specific temperature over a specific period.

However, there are several arguments that the fresh plantain is more nutritious than the processed ones because of its wholesome such as considerable moisture content as well as other classification of food present in it. It has been assumed that the drying methods applied to preserve it must have as well drain off other of its qualities.

This research work aims at projecting the nutritional quality of fresh plantain pulp versus dried plantain flour.

Materials and methods

Materials

Crucible, thread, beaker, Conical flask, beaker, distilled water, reagents bottle, chloroform, water bath, acetic acid, pipette, HCl, H2SO4, weighing balance, filter paper, heating mantle etc.

Sample preparation

A bunch of plaintain comprising 25 matured fingers was bought from Oja-Oba market Irun Akoko, Akoko North West local government Ondo state Nigeria.

The plantain bunch was detached, peeled and was divided into four parts. One part was sundried for two weeks, one part was air-dried for nine weeks, one part was oven dried for 24hrs at 105 Degree conscious and the last part was taken to laboratory immediately for the laboratory analysis.

The other three parts were dried separately and was pulverized and kept inside airtight container for laboratory analysis.

Methods

Proximate analysis

a) Percentage fats determination

A clean filter paper that is fat free was weighed (W1) and 5g of the sample was added to the filter paper and was weighed again (W2). This was then tied with thread and dropped inside the thimble of the Soxhlet apparatus. About 250ml of petroleum ether was poured into the round bottom flask of the apparatus. The Soxhlet apparatus was set up on a heating mantle and the extraction process was done for four hours in order to extract the fat with the help of the solvent. Petroleum ether siphoned over the barrel, the condenser was detached and the thimble was removed.

The solvent-extract (lipids) mixture was carefully poured into a clean dried Petri dish and transferred into a fume cupboard for 2 hours and the solvent evaporated and it was remaining the fats that were extracted. The filter paper containing the residue was dropped in a beaker and then in an oven at 50°C and was dried to a constant weight. The filter paper was later cooled inside desiccators and reweighed again (W3). The percentage fat was calculated.

$$\% \text{ Fat content} = \frac{W2 - W3}{W2 - W1} \times \frac{100}{1}$$

b) Percentage moisture determination

The moisture content was determined by using drying method which is based on weight loss.

Clean and dry crucible was weighed by using weighing balance and its weight was recorded (W1), sample was added into the empty crucible and their weight was also recorded (W2).

The crucible containing the sample was transferred into the oven maintained at 105°C and was dried for four hours. The dish was transferred from the oven into desiccators and was cooled for one hour and was reweighed again (W3). The percentage moisture content was calculated.

$$\text{Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

c) Percentage ash determination

A crucible that is ash free was weighed and the weight was recorded (W_1). 2g of sample was weighed into the crucible (W_2) and was transferred into the muffle furnace and the muffle furnace was ignited at 600 C for four hours until a grayish white substance was obtained. The crucible was transferred from the muffle furnace into a desiccator and was cooled and was reweighed again (W_3).

The percentage ash content was calculated;

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

d) Percentage crude fibre determination

5g of the defatted sample was weighed (W_1) into 2500ml of conical flask. 200ml of 1.25% H_2SO_4 was added and was brought to boiling 30minutes then was allowed to cool and was filtered through poplin cloth by suction using Bunchier funnel and was rinsed well with hot distilled water. The residue was scrapped back into flask with spatula and 200ml of 1.25% NaOH was added and was boiled gently for 30minutes and was cooled and filtered through poplin cloth and was washed with hot distilled water, and once with 10% HCL, four times again with hot water, twice with methylated spirit. The residue was savage into crucible after drain, and was dried in an oven at 105°C and cooled in desiccator and was weighed (W_2). The crucible containing the residue was placed in muffle furnace at about 300°C for about 30 minutes, and removed into desiccator and cooled to room temperature and weighed again (W_3).

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{W1} \text{ x } 100$$

e) Determination of percentage protein

2g of sample was weighed into 50ml kjedahl flask, and 12.5ml of concentrated H_2SO_4 was added with one kjedahl catalyst tablet. The flask was heated on a heater with a low heat for about 15minutes, and increase to medium heat for about 30minutes and finally at high heat until digested. The flask was rotated at intervals until the digest is clear, and the heating continue for few after that to ascertain completed digestion. The flask was allowed to cool and the sample residue was washed and filtered, to make the digest up to 50ml (V_1).

After the digestion was completed, 5ml of 2% boric acid (H_3BO_3) was placed into 100ml conical flask (as receiving flask) and 3 drops of mixed indicator was added. The receiving flask, was placed so that the tip of the condenser tube is below the surface of the boric acid, out of the 50ml of the digest 5ml (V_2) was pipetted into the distillation tube and 10ml of 40% NaOH was added. The heater was turn on and the distillation continues until approximately 50ml of distillate has been collected into the receiving flask, and then the heater was tum off. The it was titrated with 0.01M HCl and blank was titrated with the acid as well.

$$\% N = \frac{M \text{ x } T \text{ x } 0.014}{W} \text{ x } \frac{V_1}{V2} \text{ x } \frac{100}{1}$$

% protein = % N x 6.25

f) Carbohydrate content determination

The term carbohydrate embraces in broad spectrum of compound ranging from simple monosaccharide to complex polysaccharides. This carbohydrate content determination was done by subtracting of the sum of all the nutrient content determination from total weight.

CHO = 100 - (% protein + % fat + % ash + % moisture + % fibre)

Phytochemical screening

Test for tannins

Each sample (0.30g) was weighed into a test tube and boiled for 10 minutes in a water bath containing 30cm3 of water. Filtration was carried out after boiling using number 42 (125mm) whatman filter paper. To 5cm3 of the filtrate was added 3 drops of 0.1% ferric chloride. A brownish green or blue-black coloration showed positive test. (Eikeme *et al.,* 2009).

Test for phlobatannins

To each sample (0.30g) weighed into a beaker was added 30cm3 of distilled water. After 24hours of extraction (10cm3) of each sample was boiled with 5cm3 of 1% aqueous hydrochloric acid.

Deposit of red precipitate showed positive test (Eikeme *et al.,* 2009).

Test of saponnin

Distilled water (30cm3) was added to the sample (0.30g) and boiled for 10minutes in water bath and filtered using whatman filter paper number 42 (125mm). A mixture of distilled water (5cm3) and filtrate (10cm3) was agitated vigorously for a stable persistent froth. The formation of emulsion on addition of three drops of olive oil showed positive result (Eikeme *et al.,* 2009).

Test for steroid

Each sample (0.30g) weighed into a beaker was mixed with 20cm3 of ethanol. The component was extracted for 2hours. To the ethanol extract of each sample (5cm)3 was added 2cm acetic anhydride followed with 2cm3 of concentrated tetraoxosulphate (vi) acid. A violet to blue or green colour change in sample indicates the presence of steroids (Eikeme *et al.,* 2009).

Test for terpenoids

Each wood powder sample (030g) was weighed into a beaker and extracted with 30cm3 and component extracted for 2 hours. A mixture of chloroform (2cm3) and concentrated tetraoxosulphate (VI) acid (3cm3) was added to 5cm3 of each extract to form a layer. The presence of a reddish brown coloration at the interface shows positive results for the presence of terpenoids (Eikeme *et al.,* 2009).

Test for flavovoids

Each sample (0.30g) weighed into a beaker was extracted with 30cm3 of distilled water for 2hours and filtered with whatman filter paper number 42(125mm). To 10cm3 of the aqueous filtrate of each Sample extract was added 5cm3 of 1.0m dilute solution followed by the addition of 5cm3 of concentrated tetraoxosulphate (vi) acid. Appearance of yellow colouration which disappeared on standing shows the presence of flavonoids (Sofowara and Harborne**).**

Test for proteins

The extract (100 mg) is dissolved in 10 ml of distilled water and filtered through Whatmann No. 1 filter paper and the filtrate is subjected to test for proteins.

Biuret test

2 ml of filtrate is treated with 1 drop of 2% copper sulphate solution. To this 1 ml of ethanol (95%) is added, followed by excess of potassium hydroxide pellets. Pink colour ethanolic layer indicates the presence of protein (Gahan. P.B. *et al*.1984) [25].

Test for alkaloids

a) Mayer' s test

To a few ml of plant sample extract, two drops of Mayer's reagent are added along the sides of test tube. Appearance of white creamy precipitate indicates the presence of alkaloids. (Evans. W.C, *et al*. 1997) [21].

b) Wagner's test

A few drops of Wagner's reagent are added to few ml of plant extract along the sides of test tube.

A reddish- Brown precipitate confirms the test as positive. (Wagner. H, *et al*. 1993) [42].

Test for glycosides

For 50 mg of extract is hydrolyzed with concentrated hydrochloric acid for 2 hours on a water bath, filtered and the hydrolysate is subjected to the following tests.

Borntrager's test

To 2 ml of filtered hydrolysate, 3 ml of chloroform is added and shaken, chloroform layer is separated and 10% ammonia solution is added to it. Pink colour indicates presence of glycosides (Evans. W. C, *et al*. 1997) [21].

Test for carbohydrates

Molish's test

To 2 ml of plant sample extract, two drops of alcoholic solution of α- naphthol are added. The mixture is shaken well and few drops of concentrated sulphuric acid is added slowly along the sides of test tube. A violet ring indicates the presence of carbohydrates.

Determination of mineral composition

Each sample was analyzed for mineral contents like calcium, magnesium, sodium, potassium, iron by instrumentation using atomic absorption spectrophotometer (AAS Model; 2000).

The method of AOAC (1997) was employed for the determination of ash and mineral content. Two grams of the pulverized samples were placed in a crucible, and ignited in a muffle furnace for 4hrs at 550 C and then cooled in a desiccator and weighed at room temperature to get the weight of the ash. To the resulting ash, mixture of concentrated nitric acid and hydrochloric acid in ratio 1:3 was added, it was made up to 100ml with distilled water in a measuring cylinder. It was poured into a beaker and filtered then poured inside a sample bottle and kept at room temperature. This solution was used for the determination of mineral content. Atomic absorption spectrophotometer (AAS) was used to determine Mg, Fe, Mn, Cu, Ca, K, Na, Zn. Etc.

Results and discussion

Table 1: Results of phytochemical screening

S/N	Parameters	SPF	OPF	APF	FPP
1	Alkaloids	-	-	-	-
2	Carbohydrates	++	++	+++ +++	+++
3	Proteins	+	+	+	+
4	Phytosterols	++	++	+++ +++	+++
5	Glycoside	-	-	-	-
6	Saponnins	-	-	-	-
7	Tannins	-	-	-	-
8	Phlobatanninss	-	-	-	-
9	Terpenoids	-	-	-	-
10	Flavonoids	-	-	-	-
11	Steroids	-	-	-	-

+++ Highly Preaent, ++ (Very present), +(Present), - (Absent).

Discussion

The four samples of plantain were screened for phytonutrients and it was investigated that saponins, terpenoids, flavonoids, steroids tannins, phlobatannins, glycosides were absent while alkaloids, Phytosterols protein and carbohydrates were present in all the samples.

Table 2: Results of mineral composition of plantain samples (PPM)

S/N	Nutrients	SPF	OPF	APF	FPP
1	Na	0.12±0.00	0.119 ± 0.00	0.125±0.00	0.154±0.00
2	Ca	0.213±0.01	0.215±0.01	0.221±0.01	0.312±0.00
3	Mg	0.195±0.01	0.19±0.00	0.215±0.00	0.181±0.00
4	Fe	0.6105±0.01	0.825±0.02	0.65±0.00	0.921±0.00
5	Mn	0.125±0.00	0.810±0.01	0.140±0.00	0.711±0.00

Mineral is an inorganic matter which cannot be destroyed by high heat. They have low volatility compared to other food classifications. Iron has the higher values in all the samples having the fresh sample the highest anyway (Fe 0.6105±0.01 SPF, 0.825±0.02 OPF, 0.65±0.00 APF, 0.921±0.00 FPP). The decrease in the iron content of the dried samples suggests the anti-nutritional factors, oxalate and phytate could be present in the sample, thereby making the mineral unavailable by forming complexes with them, as reported by Enonfon-Akpan and Umoh, (2004) [20]. The calcium content in fresh sample (0.312±0.00), was higher than others (Ca 0.213±0.01 SPF, 0.215±0.01 OPF, 0.221±0.01 FPP). The increased in Sodium (Na 0.12±0.00 SPF, 0.119 ± 0.00 OPF, 0.125±0.00 APF, 0.154±0.00 FPP), Magnesium (Mg 0.195±0.01 SPF, 0.19±0.00, OPF 0.215±0.00 APF, 0.181±0.00 FPP). And manganese (Mn 0.125±0.00 SPF, 0.810±0.01 OPF, 0.14O±0.00 APF, 0.711±0.00 FPP) observed in this study could be because of the reduced moisture content which tends to increase concentration of nutrients per 100g of a sample between the different methods of processing used (Morris, *et al*., 2004) [32]. It was observed that both sun drying and air

drying processes were slower than oven drying, it is obvious that this prolonged drying period could leave rooms for several biological or chemical reactions to occur under atmospheric conditions, that in most cases may in turn affect the odor and color and consequently reducing the availability of the nutrient.

Table 3: Results of proximate analysis in percentage (%)

S/N	Nutrients	SPF	OPF	APF	FPF
1	Moisture	15.263±0.02	11.014±0.05	14.925±0.01	58.783±0.00
2	ASH	1.501±000	1.790±0.00	1.721 ±0.00	2.000±0.01
3	Fat	1.163±0.01	1.002±0.00	1.211±0.00	1.894±0.00
4	Crude fible	11.217±0.0	11.409±0.09	11.501±0.01	2.191±0.00
5	Crude protein	7.522±0.01	7.277±0.02	7.158±0.05	7.964±0.00
6	Carbohydrate	63.334±0.02	67.508±0.01.	63.484±0.02	27.168±0.02
7	Organic matter	85.531±0.08	82.901±0.06	83.932±0.03	38.974±0.03
8	Dry matter	79.723±0.06	87.011±0.05	81.7540.07	39.785±0.05

The moisture content for the plantain samples SPF, OPF, APF, FPP were determined to be 15.263%, 11.014%, 14.925% and 58.783% respectively. The FPP (fresh plantain pulp) contains the highest moisture content compared to others. This result implies that FPP will have lower shelf life because the high moisture content will influence the growth of microorganisms which could inturn lead to deterioration, that is FPP will spoil due to a convenient medium for microbial growth.

The moisture content of the OPF (11.014%) and SPF (15.263%) samples are in agreement with these results (11.03% oven dried) and (13.00% sundried) which was reported by Agoyero *et al*. (2011).

Moisture content of food or processed products enables both researchers and consumers to predict shelf life. Low moisture content enables the food to be stored for long period of time. Food with higher moisture level cannot be stored for a longer period, because fungal growth is bound to be observed on such food sample which in turn could cause food poisoning such as aspergillosis. Since a well dried food sample withstands fungal and other microbial growth better during storage, oven dried, air dried and sundry flour samples gave considerably lower moisture contents, hence should be encouraged.

Fat, which is the total lipid content of the plantain was determined in the four plantain samples SPF, OPF, APF, FPP to be 1.163%, 1.002%, 1.211%, and 1.894% respectively can be compared (Agoyero *et al*. (2011) who reported that unripe plantain samples gave the following values 2.75% (fresh), 1.38% (sundried) and 1.57% (oven dried) while Adepoju *et al*. (2012) reported 1.50% (fresh) and 3.90% (sundried). The fat content of the fresh sample is a bit higher than the flour samples. Meanwhile the there are no significant differences between the other three flour samples. These results are largely in agreement. Variations could be due to intensity of heat applied during the drying process, extent of dryness because sun drying has no specific way of assessment and regulation. Nutrients have been reported to be lost as a result of chemical changes such as oxidation. Lipid oxidation is known to be increased by many factors such as heat, sun light and radiations (Savage *et al*., 2002).

Crude fibre represents the content of the non-digestible components of food, such as lignin, cellulose and hemicelluloses. These are essential in animal nutrition. The crude fibre of the FPP 2.191% is significantly low when compared to other flour samples SPF 11.217+0.05, OPF 11.409+0.09, and APF 11.501+0.01. A high fiber diet normalizes bowel movements, increases the weight and size of stools wchic can be helpful if one is suffering from constipation. Eating a high in fibre has been linked to lower risk of obesity, type 2 diabetes, heart disease, bowel cancer, constipation and hemorrhoids. High fibre foods are filling which may make u stay at a healthy weight.

There are no significant differences in the protein content of the four plantain samples. The protein content of SPF, OPF, APF and FPP was determined to be 7.522%, 7.277%, 7.158% and 7.964% respectively. Diet high in protein enhances energy, repairs warn out tissues and many more.

Ash is the inorganic component of a sample after the organic matter and water have been removed by burning. Ash contents were determined to be (1.501% SPF, 1.790% OPF, 1.721%APF, 2.000% FPP). The ash content of the fresh sample is higher than others. The dry matter content was (79.723 SPF, 87.011 OPF, 81.754 APF, 39.785 FPP). While the organic matter content was (85.531, 82.901, 83.932, 38.974±) for SPF, OPF, APF, and FPP respectively.

The carbohydrate content of the fresh pulp sample (FPP 27.168%) Is low compare to other three flour sample SPF 63.334%, OPF 67.508% and APF 63.484%. The carbohydrates level in oven dried flour sample is higher than other two dried samples.

Conclusion and recommendations

According to the results obtained from this research work, the three drying methods including the fresh plantain pulp were all good because they all have nutritional constituents with minimal differences from each other. However, in order to have an increased level of all these nutritional constituents, the fresh plantain pulp is recommended. In the other hand, for longer storage, the dried samples are highly recommended. To obtain fast drying, and yet conserved protein, iron, and other nutritional contents, the oven drying method is recommended, while the sun-drying method which is a readily available method and easily executed, takes a longer time and may be exposed to contaminations from the environments. In same opinion, air drying method of food processing in this study helps the retention of the nutritional content, nevertheless could also be exposed to contamination from the environment and it

also takes the longest period to dry compared to other two drying processes used in this work.

References

1. Abiodun O, Akinoso R. Textural and sensory properties of trifoliate yam (Dioscorrea dumetorum) flour and stiff dough ‘amala’ J of Food Sci and Technol. 2014;52(5):2894-2901.
2. Ablude FO, Ojediran VA. Development and quality evaluation of fortified amala; Acta Sci. Pol. Technol. Aliment. 2006;5(2):127-134.
3. Amusa TA. Competency improvement need of farmers in cocoyam production in Ekiti state Nigeria. An unpublished PGDTE project submitted to the Department of Vocational teacher education. University of Niferia Nsuka, 2009.
4. Anugwom GA. Entrepreneurship in Nigeria. Principle and Practises. Enugu Rhyee Kerex Publishers, 2007.
5. AOAC. Official methods of analysis, Association of official and analytical chemists, Washington, 1990.
6. AOAC. Official methods of analysis, Association of official and analytical chemists, Washington, D.C. USA, 15th Edn, 1990, 807-928.
7. AOAC. Official Methods of Analyses, Food Compositions; Additives, Natural Contaminants). Association of Official Analytical Chemist (15th Ed; 980.13), Arlington, USA, 1990.
8. Arinola SO, Ogunbusola EM, Adebayo SF. Effect of drying method on the chemical, pasting and functional properties of unripe plantain (*Musa* × *paradisiaca*) flour British Journal of Applied science and technology. 2016;14(3):1-7.
9. Armola SO, Ogunbusola EM, Adebayo SF. Effect of drying methods on the chemical, pasting and functional properties of unripe plantain (Musa paradisraca) flour. British Journal of Applied Science and Technology. 2010;14(3):1-7.
10. Awodoyin R. Plantain production as a business Hon. Magazine. 2003;1(1):11-13.
11. Awoyala W, Maziya-Dixon B, Sanni L, Shittu TA. Nutritional and sensory properties (DSG) J of Food Agric and Environ, 2010.
12. Baiyeri KP, Aba SC, Otitoju GT, Mbah OB. The effect of ripening and cooking method on mineral and proximate composition of plantain (Musa SP AAB cv “Agbagba” friut pulp Afric J. Biotech. 2011;10(36):6979-6984.
13. Yarkwan B. Effect of storage method on some biochemical parameters in stored yam tubers. A.B. Tech Thesis submitted to the department of Biochemistry. Federal University of Minna. Niger State. Nigeria unpublished, 2004.
14. Ekikeme CM, Ezeonu CS, Eboatu AN. “ Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta Area of Nigeria”, European D.C. USA 15th Edn, 807-928.
15. De Langhe E, Vrydaghs L, De Maret P, *et al*. Did back crossing contribute to the origin of hybrid deible banana? Ann Bot, 2009.
16. Decter J, Tessera M, Alemu K, Abate T, Swennen R. Ensete In: Racmaekers RH (ed) crop poduction in tropical Africa. DGIC, Brussels, 2001.
17. Delanghe E, Vrydaghs L, De Meret P *et al*. Why bananas matter: an Introduction to the history of babana domestication. Ethnobot, 2009.
18. Demirel D, Turhan M. Air drying Behaviour of Divart cavendish and Gros Micheal banana slices. Journal of Food Engineering. 2003;59:1-11.
19. Emperatiz PD, Ronald M, Elvina P, Milly S. Production and characterization of unripe plantain (*Musa* × *paradisiaca*) flour. Interciencia. 2008;33:290-296.
20. Enomfon-Akpan J, Umoh IB. Effects of heat and tretracycline treatments on the food, 2004.
21. Evans WC. “Treaseand Evans Pharmacognosy”, Harcourt Brace and company. Asia Pvt. Ltd. Singapore, 1997.
22. Fakayode BS, Rahji MAY, Ayinde O, Nnom GO. An economic Assesment of plantain production in rivers state. Nigeria International Journal of Agricultural Economics a Rural Development, 2011, 42.
23. FAO. Food and Agricultural organization Report on plantain multiplication Rome. Food and Agricultural Organization, 2003.
24. FAO. Statistics series No 95 FAO, Rome, 2009.
25. Gahan PB. “Plant Histochemistry and Cytochemistry: An Introduction. Academic Press, Florida, U.S.A, 1984.
26. Gibbon D, Pain A. Crops of the drier regions of the Tropics. ECBS, pp221-235. International Institute of Tropical Agriculture, (IITA). Methods of mineral analysis, 1985.
27. Janssens SB, Vandelook F, De Langhe E, *et al*. Evolutionary dynamics and biography of musaceae reveal a correlation between the diversification of banana family and the geological and climatic history of Southeast Asia, 2016.
28. Kari OR, Kayode RMO, Adeoye and Oyeyinka AT. Proximate, material and sensory qualities of ‘Amala’ prepared from yam flour fortified with moringa leaf powder food sci and quality management. 2013;12:10-22.
29. Lemare H, Reyes M, Ngalni JA, Tchango J, Guillanmont A. Aptitude la friture de cuttrar de plantains et bananas a cuire fruits, 1997.
30. Keller M, Arnink KJ, Hrazdina G. Am. J. Enol. Vitic. 1998;49:333.
31. Reyes FGR, Wrolstad RE, Cornwell CJJ, J. AOAC. 1982;65:126.
32. Morris AA, Barnett B. Effects of processing on nutrient content of foods. Cajarticles. 2004;37:160-164.
33. National Bureau of Statistics (NBS). Consumption Pattern in Nigeria, 2009-2010. Preliminary, 2012.
34. Olorunda AO, Adelusola MA. Screening of plantain/Banana cultivar for import, storage and processing characteristics. Paper presented at the international symposium on genetics improvement of banana for resistance to disease and pest 7-9th September, (IRAD, Montpelliar France), 1997.

35. Olumba CC. Productivity of improved plantain Technologies in Anambra state, Nigeria. African Jornal of Agricultural Research. 2014;9(29):2196-2204.
36. Onyejubu CA, Olorund AO. Effect of raw material processing condition and packaging on the quality of plantain chips, Journal of the science food and Agricultural, 1995.
37. Opeke LK. Tropical commodity Tree Ibadan. Spectrum Books University Publishers. Pellerin P, Cabanis JC, Flanzy C. Oenologie Fondaments Scientifiques et Technologiques, Technique and Documentation, Paris, p. 40 (1998). quality and acridity factors in cocoyam Xanthosoma sagittifolium (L) Schott. Pakistan J. Nutri. 2005;3:240-243.
38. Rasheed A. Plantain as a business. Hort magazine vol. 1 pp 1-12Report of March, 2012. P8. Scientific Journals. 2013;10(8):247-270.
39. Skinner I. Plantain and Banana London. Macmillian Piblisher ltd, 2005.
40. Tsegaye A, Struik PC. Analysis ofenset (ensete ventricosum) indigenous production methods and farm base biodiversity in major enset-growing regions of southern Ethopia. Explor Agric, 2002.
41. Ukhum, Ukpebor. Production of instant plantain flour sensory evaluation and physio-chemical changes during storage food chemistry. 1991;42:287-299.
42. Wagner H, Pharmazeutische Biologic", 5 th Edition, AUFI.15 BN 3-437-20 498-X, 1993.