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EVALUATION OF THE EFFECT OF THREE LOCAL PROCESSING METHODS ON THE DIETARY MINERAL ELEMENT CONTENT OF *MUSA PARADISIACAL*

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Abstract: In Nigeria, *Musa paradisiacal* are eaten after cooking or after some other forms of processing. The cooking or processing method employed influences the biochemical and nutritional composition thereafter. In this study, ripe plantain fruits were analyzed after boiling, frying and roasting alongside the unprocessed ripe and unripe fruits as the control. Investigations were done in triplicates. There were significant differences ($p \leq 0.05$) in the mineral contents between the three processed samples as well as the controls. Potassium, phosphorus, iron and sodium levels were significantly ($P<0.05$) higher in the fried sample, while calcium, magnesium and zinc concentrations were significantly ($P<0.05$) lower after frying. Zinc, calcium and iron concentrations were significantly higher in the boiled sample, while magnesium, potassium, phosphorus and sodium were significantly ($P<0.05$) lower after boiling. Roasting significantly ($P<0.05$) increased the concentrations of magnesium, calcium, zinc, potassium, iron and sodium, while phosphorus level was slightly but significantly reduced. We may therefore conclude based on the results of this study that roasting, having conserved most of the mineral elements of the fruit than boiling and frying is the best method of *Musa paradisiacal* processing followed by frying. Therefore to optimize mineral elements gotten from eating plantain fruits, roasting ripe fruits is the best option for consumption.
Keywords: Plantain, micronutrients, frying, boiling, roasting.

Introduction

Musa paradisiacal (Plantain) is a perennial and herbaceous plant belonging to the family *Musaceae* and the genus *Musa*. It is a tree like perennial, with an underground rhizome. Banana also belongs to the same family and genus as plantain. In addition, the fruit is highly nutritious, containing large amounts of carbohydrates and minerals such as phosphorus, calcium, and potassium as well as vitamins A and C. Sometimes, "banana" is used as a collective term to include both bananas and plantains. The difference between the two terms "plantain" and "banana", as viewed in most parts of the world, is based purely on how the fruits are consumed. Plantains are typically eaten cooked or processed and are usually large,

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angular and starchy, in contrast to bananas, which are typically eaten raw and are usually smaller, more rounded and sugary. These cooking or processing methods employed, influence the biochemical and nutritional composition of plantain. Many plantains are hybrids derived from the cross of two wild species, *Musa acuminata* and *Musa balbisiana* which have the genome as AA and BB respectively, but all modernplantain cultivars have three sets of chromosomes (i.e. they are triploid), with AAB group as those cultivars which are used cooked, others are the AAA group (dessert banana) and ABB group. (Falana, 1997). The currently accepted scientific name for all such crosses is *Musaparadisiacal.* Plantain crops are found not only in Nigeria but in other parts of the world like the Southern United States, Central America, Southern Brazil, the Caribbean, Bolivia, Peru, Ecuador, Colombia, the Canary Islands, Taiwan, Madeira, Egypt, Cameroon and Uganda. Farmers grow plantains as far north as Northern California and as far south as KwaZulu-Natal. (Gawel, 1995). Plantain has gained acceptance as a common, reliable all-season staple food used in regions where they are found because its perennial nature makes it available all year round. In Africa, the attractiveness of plantain farming among the population is due in part to its contribution to food security, employment, diversification of income resources in rural and urban areas, low labour requirements for production compared with cassava, maize, rice and yam contribution to the gross national products (GNP), (Nkendah, 2003; Marriott and Lancaster, 1983). African countries were named among the top ten world producers of plantain with Nigeria as the world's largest producer and consumer of this crop (10.5 million tons per annum), accounting for approximately 10% of total global production (FAOSTAT, 2006).

The growing demand for plantain snacks and delicacies has been forcing prices up above that affordable by the poor, to whom it is a major carbohydrate source. High energy returns per unit of labour gives it an advantage over other starchy foods like yam, cassava or cocoyam where labour is an important production constraint. Therefore, they are sources of the cheapest carbohydrate food in terms of cost per hectare, per tonne and per calorie. (Ogazi, 1982). In plantain fruit utilization, boiling, steaming, roasting and dip-frying are the major cooking methods employed.

Materials and Method

Sample collection and preparation: Ripe and unripe plantains were purchased from Wamba market, Wamba, Nasarawa state, Nigeria. The samples were washed under running tap water and then peeled using a clean knife. The peel was discarded and the pulp processed and used for analysis. The peeled samples were chopped into smaller pieces (to facilitate drying after frying) and fried in hot vegetable oil until both sides turned golden brown. The fried plantain was taken out of the oil and placed in aluminum foil paper and covered to prevent contamination prior to processing.The second group of the ripe fruit pulp was roasted with the peel over hot charcoal and after sometime, the peel was removed as roasting continued until they were ready for consumption. The last category of the fruit pulp were washed and cut into two pieces then boiled (for about 30 minutes) in a pot containing 500 ml of water.

These processed plantain together with their ripe and unripe (both raw, used samples as control) were further sliced and air dried for a week, then sun dried for five days and finally oven dried at 90°C until permanent dry weights were obtained. Drying was carried out in a drying oven. After cooling in a desiccator, the samples were ground and final weights were taken.

These five samples in fully ground form were taken to the Chemistry advanced laboratory of Shedda Science and Technology Complex (SHESTCO), Gwagwalada, Abuja, Nigeria. All determinations were done in triplicates and the mean value was used in the calculations.

Sample Digestion and instrumental measurements of the mineral elements

The samples were digested (in a fume cupboard) on a hot plate, to destroy organic matters in the food sample before mineral determination.

2g of the homogenous sample was accurately weighed into a pyrex glass conical flask. 10mL of 65% HNO_3 was poured into the conical flask using a volumetric pipette. The mixture was heated on a hot plate for a long time until a clear digest was obtained and the fume seized. Drops of distilled water were added to the mixture so that sample does not dry up. Sample was removed from the hot plate and allowed to cool to room temperature. After cooling, the digested samples were transferred quantitatively into a 100 mL volumetric flask and diluted to mark with DI water and mixed well.The solution was filtered through Whatman® filter paper No. 541 and transferred into a clean plastic reagent bottle for mineral analysis. All glass wares were soaked with conc. nitric acid for about an hour and rinsed with distilled water before use. (Prapasri *et al.,* 2011; AOAC, 2000a). The blank was prepared by adding into a conical flask 10mL of 65% HNO_3 and heat gently then cool and transfer into a 100mL volumetric flask and make up to mark with distilled water. Here the sample to be used is not added.

The mineral content of these samples in diluted acid was determined by using a Computer Control Thermo Fisher Scientific ICE 3000 Series Atomic Absorption Spectrometer, (AAS) for Ca, Fe, Mg and Zn, but a Flame photometer for K and Na. The UV-visible spectrophotometer was used to determine phosphorus (P) by gravimetric method.

Before determining the concentration of any element in the sample, a calibration curve of the element in the sample, was prepared using prepared standard stock solutions for the elements. (AOAC, 2000a). Phosphorus was determined as phosphates (PO_4) in food products using spectrophotometric method. 5g of the sample was dissolved in 100ml distilled water and shaken for 30 minutes to have a homogenous solution.The solution was filtered using a filter paper, whatman No. 541.5mL aliquot was taken from each sample into a 50mL volumetric flask. 25mL ammonium vanadate was added to each of the sample. 5mL of ammonium molybdate was also added and made up to mark using distilled water. Varying degrees of turbidity was obtained. A blank solution was prepared as well. Sample was run in the UV-spectrophotometer at 470nm. (AOAC, 2000b).

Statistical Calculation

A test of significance (P-test) was carried out o the mean of each of the mineral element in each of the sample using a computer software- Statistical Package for Social Sciences version 15.0 (SPSS 15.0) which showed that there was a significant difference ($p<0.05$) in the mineral concentration among the various processing methods of *Musa paradisiacal*.

RESULT AND DISCUSSION

Understanding the chemical changes associated with ripening would form a basis for expanding the utilization of plantains. It is important to note that heating itself does not affect mineral levels, but other factors such as the processing method and surrounding conditions in the diet have more bearing. In this study, we shall compare the mineral content of ripe plantain processed by boiling, roasting and frying. Though minerals are not lost due to heat, but are usually leached if cooked in boiling water or any syrup. (Ebuehi, 2005). Most of the mineral quantities were influenced by the cooking method employed.

Earlier studies on the biochemical composition of plantain fruits (Ketiku, 1973; Asiedu, 1987; Izonfuo and Omuaru, 1988; Baiyeri, 2000; Baiyeri and Unadike, 2001) reported significant variability in nutrient composition of ripe and unripe fruits. Baiyeri (2000) found significantly higher doses of N, P, K, Mg and Ca in fully ripe plantain pulp (when compared to the unripe), but lower concentrations of Fe, Cu, Zn and Na in the ripe state. Results of similar studies (Baiyeri and Unadike, 2001; Baiyeri *et al.,* 2009) reported higher ash content in ripe fruits suggesting that tissue breakdown during ripening causes some mineral elements to be free and more available. In this study, it was observed from table 4.1 that the concentrations of Ca, Mg and P were higher in ripe than unripe plantain while the concentrations of Na and Fe were much lower in the fully ripe than the unripe state. This observation strongly agrees with the previous studies mentioned above. However, little disparities were recorded in the concentrations of K being lower in the ripe state [which agrees with the findings of Nwaichi *et al.,* (2014)] and Zn being higher in the ripe state.

Table 4.1: Elemental Composition of processed *Musa paradisiacal* in (mg/100g)

SAMPLE	Ca	Mg	K	P	Zn	Fe	Na
RIPE	53.5	28.1	663.1	48.0	0.48	1.25	18.0
UNRIPE	50.0	28.0	718.5	41.0	0.38	1.28	24.0
BOILED	68.1	27.8	639.5	43.0	1.10	2.05	16.0
FRIED	46.1	27.8	689.5	59.0	0.47	1.80	34.0
ROASTED	63.6	28.3	716.0	45.0	0.71	3.24	29.0
MEAN	56.25	28.0	685.32	47.2	0.69	1.92	24.2
± S.D	±9.27	±0.21	±34.1	±7.09	±0.29	±0.81	±7.50

Values represent means of triplicates. All values are significantly different at $p \leq 0.05$

There was a significant difference ($p<0.05$) in the concentrations of these elements across the ripe and unripe state.

From table 4.1, Potassium is the most abundant mineral in all the samples with the highest concentration in the unripe sample. This agrees with the results in a recent study by Nwaichi *et al.,* (2014). The concentration of potassium in the processed samples varied in the order, roasted (716mg/100g)> fried (689.5mg/100g)> boiled (639.5mg/100g). Small increases in potassium, zinc, Iron, sodium and calcium content were observed as samples were processed. The concentration of magnesium during processing remained fairly constant but slightly higher in the ripe sample. This agrees with the results of a similar study by Welford and Victor, 2006.

Baiyeri *et al.,* 2011 reported that boiling particularly at the ripe stages significantly ($P < 0.05$) reduced the zinc content of the fruit. This is in contrast to the findings in this study as a higher concentration of zinc was observed in the boiled sample. A higher concentration was also obtained for calcium and iron after boiling. This is probably due to the presence of trace amounts of these elements in the water used for boiling (probably hard water) and there is a tendency of these samples to pick up these elements from the water used, thus the increase in concentration. The reverse was the case in the levels of magnesium, potassium, phosphorus and sodium as a significant decrease was observed in the levels of these minerals after boiling. This observation could be as a result of leaching or volatilization losses of these minerals through the cooking medium (water). (Ebuehi, 2005). He recorded significant losses in various minerals including Ca, Mg, P, Fe, Na and Cl in the roots and fresh leaves of cassava as a result of boiling.

Boiling and dipfrying had been implicated in the reduction of certain micronutrients in plantain pulp including iron, copper and zinc (Ahenkora *et al.,* 1996). In that study, it was reported that steam-cooking of the fruit pulp in polyethylene wraps minimized nutrient losses from the fruit pulp. The polyethylene wrap provided a barrier between the pulp and the cooking medium thereby protecting the edible pulp from possible nutrient losses.

Significantly ($p<0.05$) higher levels of potassium, phosphorus, iron and sodium were observed in samples processed by frying. In contrast, calcium, magnesium and zinc concentrations were significantly ($P<0.05$) lower. This is obvious as zinc loss has also been implicated in dip frying method as stated in a study by Ahenkora *et al.,* 1996.

Roasting significantly ($P<0.05$) increased the concentrations of magnesium, calcium, zinc, potassium, iron and sodium, while phosphorus level was slightly but significantly reduced. These increased concentrations after roasting could be due to increased concentration of the minerals in the pulp through loss of water during the roasting process. (Baiyeri *et al.,* 2011). During roasting, a surface crust is readily formed around the sample sealing intercellular spaces; this could be the reason for the minimized losses that may have arisen as a result of possible volatilization.

From table 4.1, the ratios of Sodium to Potassium (Na/K) and Calcium to Phosphorus (Ca/P) can be calculated. Na/K ratio is of great importance for prevention of high blood pressure. Na/K ratio less than one is recommended, and from the result obtained, the three processing methods as well as the controls, offered a value <1 for the Na/K ratio. It can thus be inferred that these 3 methods of plantain processing have good health implications and would probably reduce the risk of high blood pressure (NRC, 1989).

Diets rich in protein and Phosphorus may promote the loss of Calcium in the urine (Shills and Young, 1988); this had led to the concept of the Ca/P ratio. Adeyeye and Fagboun (2005) reported that a Ca:P above two (twice as much as Calcium and Phosphorus) helps increase the absorption of calcium in the small intestine. Food is therefore considered “good” if this ratio is >1 and “poor” if the ratio is < 0.5. (Nieman *et al*., 1992). From the table, after calculation, it was observed that all processed samples as well as controls had Ca/P ratio fairly greater than 1 and can be rated “good” to this regard except the fried sample which had a value that was <1 but >0.5.

Conclusion

Besides being an energy food, plantain as one of the major staple foods in most parts of the world has the potential to provide modest amounts of various food nutrients. Despite heat treatment given to all samples, mineral loses were minimal and these losses arose due to surrounding circumstances in the processing methods which could fairly be minimized by taking certain precautions during processing. There was a significant difference (p<0.05) in the effects of these three methods of plantain processing on its mineral levels. Roasting as a method of plantainpreparation conserved the concentration of most of the mineral elements and also increased the concentration of almost all the minerals after processing. During roasting, a surface crust is readily formed around the sample sealing intercellular spaces, thereby minimizing possible volatilization losses. It is therefore adjudged and recommended as the best method for plantain processing (cooking) as regards mineral conservation.

Recommendation

Inspite of many analyses carried out by chemists and biochemists, the data in literature remain insufficient. Limitations of this study included non-availability of adequate data for further comparison; therefore further research needs to be carried out to broaden the scope of this study and make a concise and general conclusion by considering more locally processed forms of plantain like the Plantain chips, Plantain MoiMoi (UkpoOgede), Plantain Mosa (Plan-cakes), Plantain Mosa (Plantain Puffs), and Plantain Pies and their effects on its proximate and mineral compositions.

REFERENCES

[1] Adeyeye, E.I., & Fagboun, E.D. (2005). Proximate, Mineral and Phytate profiles of some selected spices found in Nigeria. *Pakistan journal of Science and Industrial Resources.* **48 (1):** 14-22.

[2] Ahenkora, K., Kyei, M.A., Marfo, E.K., & Banful, B. (1996). Nutritional composition of False Horn *Apantupa* plantain during ripening and processing. *Journal of African Crop Science.* **4:** 243-247.

[3] AOAC, (2000a).*Official Method of Analysis of AOAC International*.17th Edition. Horwitz W (ed). AOAC International, Maryland, USA. (Methods 9.1.09 and 50.1.14).

[4] AOAC, (2000b). *Official Method of Analysis of AOAC International*.17th Edition.Horwitz W (ed). AOAC International, Maryland, USA. (Methods 50.1.12 and 50.1.15).

[5] Asiedu, J.J. (1987). Physicochemical changes in plantain (*Musa paradisiaca*) during ripening and the effect of degree of ripeness ondrying. *Tropical Science*.**27:** 249-260.

[6] Baiyeri, K.P., Aba, S.C., Otitoju, G.T. and Mbah, O.B. (2011). The effects of ripening and cooking method on mineral and proximate composition of plantain (*Musa* sp. AAB cv. 'Agbagba') fruit pulp. *African Journal of Biotechnology.* Vol. 10**(36):**6979-6984.

[7] Baiyeri, K.P. & Unadike, G.O. (2001). Ripening stages and days after harvest influenced some biochemical properties of two Nigerian plantain (Musa species AAB) cultivars. *Plant Production Research Journal.* **6:** 11-19.

[8] Baiyeri, K.P. (2000). Effect of Nitrogen fertilization on mineral concentration in plantain (Musa AAB) fruit peel and pulp at unripe and ripe stages. *Plant production Research Journal*.**5:** 38-43.

[9] Baiyeri, K.P., Ede, A.E., Otitoju, G.T., Mbah, O., Agbo, E., Tenkouano, A. &Faturoti, B.O. (2009).Evaluation of iron, zinc, potassium and proximate qualities of five *Musa* genotypes. *Journal of Applied Bioscience*. **18:** 1003-1008.

[10] Ebuehi OAT (2005). Phytochemical, nutritive and anti-nutritive composition of cassava (*Manihot esculenta* L) tubers and leaves.*Nigerian Food Journal*. 23: 40-46

[11] Falana, I. B. (1997).*Effects of low irradiation doses and some physical treatments on the keeping quality of plantain (Musa AAB).* Phd. Thesis. Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife., Nigeria.

[12] FAOSTAT, (2006).Food and agriculture organization of the United Nations. FAO Rome: *Production Year book.*

[13] Gawel, N. (1995). *Production and Characterization of Flour Produced from Ripe Plantain (Musa sapientum).*

[14] Izonfuo, W.A.L. & Omuaru, V.O.T. (1988). Effect of ripening on the chemical composition of plantain peels and pulp (*Musa paradisiaca*). *Journal of Science, Food and Agriculture*.**45:** 333-336.

[15] Ketiku, A.O. (1973). Chemical Composition of Ripe and Unripe plantain.*Journal of the Science of Food and Agriculture.***24:** 703-707.

[16] Marriott, J., & Lancaster, P.A. (1983). Banana and plantain. Chan, H.T. (ed.) In: *Handbook of tropical foods*. Marcel Dekker, New York. Pp. 85-143.

[17] Nieman, D.C., Butterworth, D.E., & Nieman, C.N. (1992). *Nutrition.* Winc Brow Publishers. Dubugne, USA. Pp 237-312.

[18] Nkendah, R., & Akyeampong, E. (2003). *Socio economic data on the plantain commodity in West and Central Africa.Info Musa.* (1): 12.

[19] NRC, National Resources Council (1989). Recommended Dietary Allowances, 10th edn.National Academy Press. Washington DC, USA.

[20] Nwaichi, E.O., Peters, D.E., and Onome, E. (2014). Evaluation of the effect of processing on the observed profile of Ripe and Unripe Plantain. *Scientia Agriculturae.* 1(1): 15-18. DOI: 10.15192/PSCP.SA.2014.1.1.1518.

[21] Prapasri, P., Tee, E.S., Julia, K., Graham, C., Rafael R.F., & Kunchit, J. (2011). (1st edition). *The ASEAN Manual of Food Analysis.*Institute of Nutrition, Mahidol University, Thailand. Pp 41-47.

[22] Shills, M.E., & Young, V.R. (1988). Modern nutrition in health and disease. In: Nutrition.