Agro Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 7 Number 2 May 2008 pp. 99 -105
ISSN 1119-7455

EFFECT OF PROCESSING ON THE PROXIMATE, MINERAL, AND PASTING PROPERTIES OF WHOLE FLOUR MADE FROM SOME NEW PLANTAIN AND BANANA HYBRIDS PULP AND PEEL MIXTURE

Adeniji, Tajudeen Adebayo and Tenkouano, Abdou
International Institute of Tropical Agriculture, P.M.B. 5320, Oyo Road, Ibadan, Nigeria.

ABSTRACT

The effect of processing on the proximate and mineral composition, as well as pasting properties of whole flour produced from a selection of new Musa hybrids generated by the International Institute of Tropical Agriculture (IITA) was investigated. Results show that blanching had significant effect (p<0.05) on the proximate composition, mineral contents and pasting properties of whole Musa flour. However, there was no significant treatment effect (p>0.05) on the moisture, potassium and zinc content of the flour. Some of the pasting properties of the flour, including peak viscosity, final viscosity, setback viscosity and pasting time were not significantly different (p>0.05) across various treatments used. This finding suggests that traditional method of peeling plantain and banana fingers without blanching could be more beneficial based on the nutrient profiles, time and resources required to accomplish the blanching process. Whole plantain and banana flour may constitute an important feeding stuff for livestock, which may eventually provide protein in human diet from consumption of meat and other products from livestock.

Key words: Processing, proximate, minerals, whole flour, hybrids, plantain.

INTRODUCTION

Plantain and banana (*Musa* spp.) are important staple crops that contribute to the calories and subsistence economies in Africa. They are good sources of carbohydrate, (Marriott, *et.al*, 1981). Plantain cultivation is attractive to farmers due to the low labour requirements for production compared with cassava, maize, rice and yam (Marriott and Lancaster, 1983). Plantain pulp is low in protein with estimated values of 4g per kg in green unripe finger, and 9g per kg in the fully ripe finger. A higher level of about 72g per kg is found in the peels, which makes the peel a suitable feeding stuff for ruminants, especially in ripe form (Izonfuo and Omuaru, 1988). Plantain peel is richer in minerals such as potassium, calcium, magnesium, phosphorus, copper and iron, except sodium, when compared to the pulp, at all stages of physiological ripeness, with increasing levels of potassium, calcium and iron as the fruits ripens (Izonfuo and Omuaru, 1988). High level of potassium in plantain makes it an important raw material for indigenous soap manufacture and in the amendment of acidic soils (Izonfuo and Omuaru, 1988). The physiological role of minerals in human diet have been documented (Ihekoronye and Ngoddy, 1985; Okaka *et al.*, 1992; Onigbinde, 2001). Rahman, *et al.* (1963) reported on the utilisation of flour from unpeeled green plantain in poultry feed, and concluded that no ill or toxic effects could be observed in the chicks fed with the flour. The authors further reported that there was no mortality in the course of the experiment, while organoleptic tests revealed that there was no difference in the colour or flavour of the meat produced.

Pasting properties is an important index in determining the cooking and baking qualities of flours (PBIP, 1995). Starch when heated increases in viscosity as a result of the swelling of the starch granules. Plantain absorbs water during cooking, which results in softening of the pulp. The amount of water absorbed depends on the duration of cooking, starch content and the cultivar (Dadzie, 1995). Studies have been conducted on the pasting properties of plantain-soy flour mixes (Abioye *et al.*, (2006). Similarly, Daramola and Osanyinlusi (2005) reported on the pasting properties of six varieties of banana in Ekiti state. High set back value, an important component of pasting properties of starch is associated with a cohesive paste and has been reported (Oduro, *et al.*, 2000) to be significant in domestic products such as pounded yam, which requires high set back, high viscosity and high paste stability. Setback value may be considered an important parameter in *Musa* spp. fruits based on their wide application in traditional recipe in many parts of Africa. In Ghana for instance, *fufu* (a mixture of boiled green plantain and cassava, pounded into a thick dough) and *ampesi* (boiled fruit) are the main household dishes usually eaten with soup or stew (Akomeah, *et al.*, 1995). Ogazi (1996) also reported that when an unripe plantain is cooked, and pounded, a meal called *fufu* is obtained, which can be eaten with soup. Both unripe and ripe plantain is cooked and pounded with boiled yam or cocoyam to improve the texture of the meal, which is usually smooth, and more elastic when compared to pounded yam or cocoyam alone (Ogazi, 1996). The production and utilisation of flour from unripe cooking banana and plantain has been reported (Oyesile, 1987). Two parts of the flours may be reconstituted in one part of boiling water, and mixed thoroughly with a wooden spatula over the heating medium to produce a thick dough, called 'amala', a traditional dish commonly eaten with vegetable soup in Western Nigeria among the Yorubas. The objective of this work was to provide information on the nutritional composition of new *Musa* hybrids in furtherance of their industrial potentials and utilisation.

MATERIALS AND METHODS

Plant materials.

Five cultivars of new plantain and banana hybrids released into the farming systems in West and Central Africa (WCA) and East and Southern Africa (ESA) were investigated, including the preferred landrace, Agbagba. These included four plantain hybrids (PITA 14, PITA 17, PITA 24, PITA 26) and a cooking banana hybrid (BITA 3). These hybrids were chosen based on their consistent agronomic performance, post harvest qualities and farmers' perception. Samples were obtained from the experimental station of the International Institute of Tropical Agriculture (IITA), High Rainfall Station, Onne agro ecology, located on Latitude 04° 43' N, Longitude 07° 01' E and 10m Altitude, near Port Harcourt, Nigeria. The soil is sandy loam Oxisol of Nkpologu series (Ndubizu, 1981). Rainfall is bimodal with an annual total of about 1500mm.

Preparation of flour.

Finger samples were collected from the second hand from the proximal end of the bunch following the recommendation of Baiyeri and Ortiz (2000) the same day the bunch was harvested. Some samples were immersed in a plastic bowl with potable water and then sliced longitudinally into two with the aid of stainless kitchen knife. Blanching was carried out on some samples by dipping fingers in hot water at 100°C for 5, and 10 minutes before slicing. Some samples were peeled and dried directly in the oven without treatment, which served as control. Sliced fruits were placed in petri dishes and covered with filter paper to prevent contamination. Drying was carried out in Forced-Air Moisture Extraction Plus II Oven, Sanyo Gallenkamp PLC, United Kingdom, at 65°C for about 48 hours and milled with the aid of stainless Kenwood Chef Warring Blender, Model KM001 (0067078) series.

Proximate analysis.

Proximate analyses for moisture, protein (N x 6.25), fat, ash, and crude fibre of samples were determined according to AOAC (1990) procedures. Carbohydrate content was calculated by difference.

Determination of Minerals.

Mineral analysis was performed using the procedure described by AOAC (1990) and Allen *et al.*, (1984). The analytical procedures used for sample treatment for AAS analysis are as follows: 1gram sample was weighed into a pyrex glass conical flask. 10ml concentrated nitric acid was introduced into the flask with a straight pipette. 5ml of perchloric acid was also added. The mixture was heated on an electro-thermal heater for about 20 minutes until a clear digest was obtained. The digest was cooled to room temperature and diluted to 50ml with distilled water. The diluent was filtered into a plastic vial for AAS analysis.

Determination of pasting properties.

Pasting properties of flour was characterised using Rapid Visco Analyser (RVA) Model 3C, Newport Scientific PTY Ltd., Sydney) as described by Delcour *et al.* (2000) and Sanni *et al.*, (2004). Five gram (5g) of sample was accurately weighed into a weighing vessel. 25ml of distilled water was dispensed into a new test canister. Sample was transferred onto the water surface in the canister, after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained neither on the water surface nor on the paddle. The paddle was placed into the canister

Table 1. Effect of blanching on the proximate composition of whole flour made from black Sigatoka resistant Musa bybrids pulp and peel mixture

Treatment	MC	Protein	Starch	Sugar	Amylose	Fat	Ash
			%				
HW-10	1.99^{a}	4.39^{b}	73.15^{a}	1.55^{b}	19.62^{b}	1.32^{b}	3.66^{b}
HW-5	1.91^{a}	4.42^{b}	70.29^{b}	1.79^{b}	23.11^{a}	1.33^{b}	4.04^{a}
CW	2.13^{a}	4.49^{b}	73.29^{a}	2.49^{a}	22.25^{ab}	1.49^{a}	4.17^{a}
C	2.25^{a}	4.61^{a}	66.64^{c}	1.43^{b}	22.31^{ab}	1.47^{a}	4.30^{a}

HW-10= Finger dipped for 10 minutes in Hot Water at 100°C, HW-5= Finger dipped for 5 minutes in Hot Water at 100°C, CW=Finger dipped in Cold Water at ambient temperature of 27-30°C; C=Control, finger peeled and dried directly, no treatment.

Values in the same column with different letters are significantly different at $p<0.05$.

Table 2. Effect of blanching on mineral composition of whole flour made from black sigatoka resistant *Musa* hybrids pulp and peel mixture

Treatment	Ca	Mg	K	P	Na	Mn	Cu	Fe	Zn
					µg/g				
HW-10	600^{b}	700^{b}	11600^{a}	1100^{b}	44.4^{c}	61.9^{ab}	5.2^{a}	141.4^{a}	8.1^{a}
HW-5	700^{a}	700^{b}	11600^{a}	1100^{b}	53.2^{a}	55.2^{b}	4.37^{b}	72.5^{c}	8.2^{a}
CW	600^{b}	710^{ab}	11600^{a}	1200^{a}	45.7^{bc}	58.8^{b}	4.43^{ab}	121.4^{ab}	8.2^{a}
C	700^{a}	730^{a}	11600^{a}	1200^{a}	49.8^{ab}	70.3^{a}	5.05^{ab}	94.6^{bc}	8.8^{a}

HW-10= Finger dipped for 10 minutes in Hot Water at 100°C, HW-5= Finger dipped for 5 minutes in Hot Water at 100°C, CW=Finger dipped in Cold Water at ambient temperature of 27-30°C; C=Control, finger peeled and dried directly, no treatment.

Values in the same column with different letters are significantly different at $p<0.05$.

Table 3. Effect of blanching on pasting properties of whole flour made from black sigatoka resistant *Musa* hybrids pulp and peel mixture

Treatment	PV	TV	BV	FV	SV	PTi	Pte
HW-10	179.3^{a}	158.5^{b}	20.7^{b}	232.2^{a}	73.7^{a}	5.9^{a}	87.7^{ab}
HW-5	179.3^{a}	158.5^{b}	20.7^{b}	232.2^{a}	73.7^{a}	5.9^{a}	87.6^{ab}
CW	185.3^{a}	158.2^{b}	26.3^{a}	235.5^{a}	77.3^{a}	5.8^{a}	87.9^{a}
C	197.2^{a}	172.8^{a}	24.4^{ab}	246.1^{a}	73.3^{a}	5.8^{a}	87.2^{b}

HW-10= Finger dipped for 10 minutes in Hot Water at 100°C, HW-5= Finger dipped for 5 minutes in Hot Water at 100°C, CW=Finger dipped in Cold Water at ambient temperature of 27-30°C; C=Control, finger peeled and dried directly, no treatment.

PV=Peak Viscosity, TV=Trough Value, BV=Breakdown Value, FV=Final Viscosity, SV=Setback Viscosity, PTi=Pasting Time, PTe=Pasting Temperature, RVU= Rapid Visco Unit.

Values in the same column with different letters are significantly different at $p<0.05$.

and both were inserted firmly into the paddle coupling so that the paddle is properly centred. The measurement cycle was initiated by depressing the motor tower of the instrument. The test was then allowed to proceed and terminate automatically. All chemical analyses were performed at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Statistical Analysis.
The data generated were analysed using Statistical Analysis Systems version 9.1 SAS (2003) software package. Significance of treatment means was tested at 5% probability level using Duncan's New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSION

Proximate composition.
Results show that blanching had no effect on the moisture content of the new *Musa* hybrids (Table 1). The protein content in the control (4.61%) differed significantly ($p<0.05$) from treated fingers. Starch obtained in cold water treated fingers (73.29%) and blanching (100°C for 10 minutes) (73.15%) are significantly different ($p<0.05$) from others. Cold water treatment also had significant effect ($p<0.05$) on sugar (2.49%) and fat (1.49) content of whole *Musa* flour. Fingers immersed in cold water (73.29%) and those blanched at 100°C for 10 minutes (73.15) had a significant ($p<0.05$) effect on the starch content of flour. Cold water treatment also had significant effect on sugar (2.49%) and fat (1.49%) content of *Musa* flour. The amylose (23.11%) obtained in fingers

blanched at 100°C for 5 minutes differed significantly ($p<0.05$) from the value obtained in fingers treated for 10 minutes, but similar to cold water treated fingers and the control. The ash content in the control (4.30%), and those of cold water treated fingers (4.17%) and fingers blanched for 5 minutes (4.04%) were significantly different ($p<0.05$) from fingers blanched for 10 minutes. Conventionally, flour is made from green plantain and banana by hand-peeling the fruits, which is often difficult and time consuming. Crowther (1979) recommended that fingers should be soaked in hot water before peeling, but this rarely helps, and, with experience, hand peeling untreated fingers can be quite successful despite its limitation. Suffice to say that blanching of fingers has no beneficial effect on the peeling, but can affect the nutrients as observed in this present study. Notwithstanding, physical pre-treatments such as blanching, osmotic pre-treatment (Sankat *et al.*, 1996) and freezing (Eshtiaghi *et al.*, 1994) have been investigated in order to improve either drying or product quality. Effect of blanching on product quality, preservation, and enzyme inactivation has been extensively studied by a number of authors (Levi *et al.*, 1980; Mowlah, *et al.*, 1981; Garcia *et al.*, 1985; Cano *et al.*, 1990a). Blanching is an important step in fruit and vegetable processing because of many advantages it can offer, one of which is to inactivate enzymes (Dandamrongrak, *et al.*, 2003). Freezing and combined blanching and freezing has been reported to increase drying rate and therefore decrease drying time of bananas.

Blanching could provide a major means of reducing processing cost through increased drying efficiency in flour processing using the new plantain and banana varieties. Further research is necessary to improve product quality because treatments that produced the greatest improvement in drying performance also has the greatest effect in reducing product quality (Dandamrongrak, *et al.*, 2003).

Mineral composition.

The effect of blanching on mineral profiles of whole *Musa* flour made from plantain and banana hybrid pulp and peel mixture is presented in Table 2. Data show that fingers subjected to 5 min blanching and the control were significantly different ($p<0.05$) in calcium (700µg/g each) compared to other methods. Control had a significant effect ($p<0.05$) on magnesium (730µg/g) compared to other methods, but similar to cold water treated fingers with 710µg/g magnesium. Blanching had no significant effect ($p>0.05$) on potassium (11600µg/g) and zinc (8.1-8.2µg/g) contents in different *Musa* flour. However, both cold water treated fingers and the control had a significant effect ($p<0.05$) on phosphorus (1200µg/g) content of flour. Fingers blanched for 5 minutes differed significantly ($p<0.05$) from others in sodium (53.2µg/g) but similar to the control (49.8µg/g). Significant different ($p<0.05$) was observed in the control experiment compared to treated fingers in manganese content (70.3µg/g), but similar to 61.9µg/g found in fingers treated in hot water for 10 minutes. Fingers treated for 10 minutes was significantly different ($p<0.05$) in both copper (5.2µg/g) and iron (141.4µg/g) contents of the flour. However, the concentration of copper was similar to the control (5.05µg/g) and cold water treated fingers (4.43µg/g), while iron content of cold water (121.4µg/g) also have similarity with fingers treated for 10 minutes in hot water. The reason for higher levels of iron in fingers treated in hot water for 10 minutes compared to other treatments cannot be explained scientifically. Ahenkora *et al.*, (1996) reported that boiling increased the moisture content of plantain pulp while frying decreased the moisture content. Green plantains absorb more moisture when boiled and lost more moisture when fried. This increase in the moisture content of plantain pulp may be due to osmosis, involving the movement of water molecules from the peel to the pulp (Aboua, 1991; Marriott and Lancaster, 1983). In this present study, unpeeled green plantains were blanched at different temperatures prior to drying. There is tendency for movement of nutrients alongside the moisture from the peel to the pulps, thereby increasing the nutrient levels in the pulp. The peel of plantain and banana like those of other fruits confer rigidity to the whole fruit and consequently protects the edible pulp from the surrounding environment. This eliminates leaching of nutrients into the cooking medium from the protected edible pulp during cooking of the entire unpeeled fruit. Ebuehi (2005) reported significant losses in various minerals including calcium, magnesium, phosphorus, iron, sodium and chloride ions identified in the roots and raw leaves of cassava as a result of boiling. Boiling and frying has also been implicated in the reduction of certain micronutrients in plantain pulp including iron, copper and zinc (Ahenkora, *et al.*, 1996). Deep-frying, baking and pickling results in substantial loss of pVACs (Rodriguez-Amaya, 1997). Freezing (especially quick freezing) however preserves pVACs, but long thawing is detrimental (Rodriguez-Amaya, 1997; Craft and Wise, 1993). This calls for adoption of appropriate processing techniques for retention of various nutrients in foods especially vitamins and minerals. Increased utilization of ripe plantain could offer significant intake of certain micronutrient, such as iron, copper and zinc, as ripening significantly increases the levels of these nutrients in plantain (Ahenkora, *et al.*, 1996).

Pasting properties.

The pasting properties of whole *Musa* flour (Table 3) are in conformity with the values reported in plantain-soy flour mixes (Abioye *et al.*, (2006) and yam starches (Otegbayo *et al*,. 2006). Blanching had no significant effect ($p<0.05$) on peak viscosity, final viscosity, setback viscosity and pasting time of whole plantain and banana flour. However, the control experiment differed significantly ($p<0.05$) from other methods in trough value (172.8 RVU), while cold water treatment was significantly different ($p<0.05$) from other methods in breakdown value (26.3 RVU), but similar to the control (24.4 RVU). Cold water treatment had a significant effect ($p<0.05$) on pasting temperature (87.9°C) compared to other methods, but similar to fingers blanched for 5 and 10 minutes.

CONCLUSION

This finding suggests that traditional method may have some beneficial effect on the nutrient profiles, time and economy of *Musa* flour production. Improved cultivars of plantain and banana may provide high quality whole flour from the entire fruit for livestock feed, which may eventually provide protein in human diet from consumption of meat and other products of livestock. Such flour may be employed in traditional dishes for human consumption based on their nutritional profiles. There is need to investigate the application of whole *Musa* flour in baking and confectioneries from the point of view of their pasting properties. The use of entire fingers of plantain and banana could be a rapid approach in flour production with improved levels of nutrients, especially minerals, which are concentrated in the peel (Izonfuo and Omuaru, 1988).

ACKNOWWLEDGEMENT

Special thanks go to Miss Jacinta Ndidiamaka Ezurike and Miss Blessing Ada Ezeagwula for assistance with sample preparation and data input

REFERENCES

Abioye, V.F., B.I.O., Ade-Omowaye and M.K. Adesigbin (2006). Effect of soy flour fractions on some functional and physico-chemical properties of plantain flour. In: (O.A.T. Ebuehi, ed). Reforms in the Food Industry for Meeting Future Challenges in Africa. Proceedings of the 30th Annual Conference/General Meeting of the Nigerian Institute of Food Science and Technology, Sheraton Hotel and Towers and ASCON Conference Centre, Badagry, Lagos State, Nigeria, 142-143.

Aboua, F. (1991). Chemical and physical changes in plantains (*Musa paradisiaca*) during ripening. Tropical Science 31: 183-187.

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

Akomeah F., L. Ohemeng-Appiah and D. Adomako (1995). Country Reports: Paper written for the Plantain and Banana Research and Technology Training Course, High Rainfall Station, International Institute of Tropical Agriculture (IITA), Onne, Port Harcourt, Nigeria. *Mus*Africa, 7: 11-13.

Allen S.E, H.M. Grimshaw, J.A. Parkinson and C. Quarmby (1984). Chemical analysis of ecological materials. Edited by S.E. Allen. Blackwell Scientific Publications, Oxford London, Edinburgh, Melbourne, 565pp.

AOAC (1990). Official Methods of Analysis of the Association of Official Analytical Chemists, 15th ed., AOAC, Arlington, Virginia, USA.

Baiyeri K.P and R. Ortiz (2000). Agronomic evaluation of plantain and other triploid *Musa*. In K. Craenen, R. Ortiz, E.B. Karamura, and D.R. Vuylsteke (eds.). Proceeding of First International Conference of Banana and Plantain in Africa, Kampala, Uganda, 12-18 October, 1996. *International Society for Horticulturae*, 540: 125-135.

Cano P., M.A. Marin and C. Fuster (1990a). Effects of some thermal treatments on polyphenoloxidase and peroxidase activities of banana (*Musa* cavendishii, var. enana). *Journal of the Science of Food and Agriculture*, 51: 223-231.

Craft N.E., and S.A. Wise (1993). Individual carotenoid content of SRM 1548 Total Diet and influence of storage temperature, lyophilization and irradiation on dietary carotenoids. *J. Agric Food Chem* 41: 208-213.

Crowther P.C. (1979). The processing of banana products for food use. Rep. Trop. Prod. Inst., G122, iv + 18pp (1979).

Dadzie B.K. (1995). Cooking qualities of black Sigatoka resistant plantain hybrids. *InfoMusa* Vol. 4, No. 2: 7-9.

Dandamrongrak R., R. Mason and G. Young (2003). The effect of pretreatments on the drying rate and quality of dried bananas. *International Journal of Food Science and Technology*, 38 (8): 877-882.

Daramola B. and S.A. Osanyinlusi (2005). Production, characterization and application of banana (*Musa* spp.) flour in whole maize. *African Journal of Biotechnology*, 5 (10): 992-995.

Delcour J.A., J. Vanstelandt, M.C. Hythier and J. Abecassis (2000). Fractionation and reconstitution experiments provide insight into the role of starch gelatinisation and pasting properties in pasta quality. *J. Agric. Food Chem.* 48: 377-378.

Ebuehi O.A.T. (2005). Phytochemical, nutritive and anti-nutritive composition of cassava (*Manihot esculenta L*) tubers and leaves. *Nigerian Food Journal*, 23: 40-46.

Eshtiaghi M.N., R. Stute and D. Knorr (1994). High pressure and freezing pre-treatment effects on drying, dehydration, texture and color of green beans, carrots and potatoes. *Journal of Food Science*, 59: 1168-1170.

Garcia R., M.C. de Arriola, E. de Porres and C. Rolz (1985). Process for banana puree preservation at rural level. *Lebensmittel-Wissenschaft-und-Technologie*, 18: 323-327.

Ihekoronye A.I. and P.O. Ngoddy (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishers Ltd., London and Basingstoke, 386pp.

Izonfuo W-A.L. and V.O.T. Omuaru (1988). Effect of Ripening on the Chemical Composition of Plantain Peels and Pulps (*Musa paradisiaca*). *Journal of the Science of Food and Agriculture*. 45, 333-336.

Levi A., J.R. Ramirez-Martinez and H. Padua (1980). Influence of heat and sulfur dioxide treatments on some quality characteristics of intermediate-moisture banana. *Journal of Food Technology*, 15: 557-566.

Marriott J. and P.A. Lancaster (1983). Bananas and Plantains, In: Chan, H.T. (ed.). Handbook of Tropical Foods. Marcel Dekker, New York, USA. pp. 85-143.

Marriott J., M. Robinson and S.K. Karikari (1981). Starch and sugar transformations during ripening of plantains and bananas. *J. Sci. Food Agric.*, 32, 1021-1026.

Mowlah G., K. Takano, T. Asari, I. Kamoi and T. Obara (1981). Inactivation behavior of enzymes and the changing pattern of some physicochemical properties during steam blanching of banana slices before further processing. *Nippon Shokuhin Kogyo Gakkashi*, 28: 620-626.

Ndubizu, T.O.C. (1981). Effect of split fertilizer application on growth and yield of Falsehorn plantain (*Musa* spp.) in the rain forest belt of Nigeria. *Der Tropenlandwirth, Zeitschrift fur die Landwirtschaft in den Tropen und Subtropen*, 82: 153-161.

Oduro I., W.O. Ellis, S.K. Aryeetey, K. Ahenkora and J.A. Otoo (2000). Pasting characteristics of starch from new varieties of sweet potato. *Tropical Science*, 40: 25-28.

Ogazi P.O. (1996). Plantain: production, processing and utilisation. Paman Associates Ltd., Imo State, Nigeria, 305pp.

Okaka, J.C., E.N.T. Akobundu and A.N.C. Okaka (1992). Human Nutrition: an integrated approach, Enugu State University of Science and Technology, Enugu, Nigeria.

Onigbinde A.O. (2001). Human Nutrition (Biochemical Integration), Ilepeju Publishers Ltd., Benin City, Nigeria, 300pp.

Otegbayo B.O., J.O. Aina and R. Asiedu (2006). Effect of storage on the pasting characteristics of yam starches. In: (O.A.T. Ebuehi, ed). Reforms in the Food Industry for Meeting Future Challenges in Africa. Proceedings of the 30th Annual Conference/General Meeting of the Nigerian Institute of Food Science and Technology, Sheraton Hotel and Towers and ASCON Conference Centre, Badagry, Lagos State, Nigeria, 187-188.

Oyesile O.O. (1987). Comparative studies on cooking banana and plantain products. MSc. Thesis, University of Ibadan, Ibadan, Nigeria.

PBIP (1995). Plantain and Banana Improvement Program 1994 Annual Report. Crop Improvement Division, International

Institute of Tropical Agriculture, Nigeria.

Rahman A.R. (1963). Economical method for the production of flour from green plantains. The *Journal of Agriculture of the University of Puerto Rico*, Vol. XLVII, No. 1: 1-10.

Rodriguez-Amaya D.B. (1997). Carotenoids and food preparation: The retention of provitamin A carotenoids in prepared, processed, and stored foods. Opportunities for Micronutrient Intervention (OMNI), Arlington.

Sankat C.K., F. Castaigne and R. Maharaj (1996). The air drying behaviour of fresh and osmotically dehydrated banana slices. *International Journal of Food Science and Technology*, 31: 123-135.

Sanni L., M. Onitilo, O.B. Oyewole, T. Keiths and A. Westby (2004). Studies into Production and Qualities of cassava grits (Tapioca) in Nigeria. Paper presented at the sixth International Scientific Meeting of the Cassava Biotechnology Network, 8-14 March 2004, CIAT, Cali Columbia.

SAS (2003). Statistical Analysis Software (SAS) Systems for Windows, SAS Institute Inc., Cary, NC, USA (2003).