Journal of Stored Products and Postharvest Research Vol. 2(8), pp. 164 – 169, August 2011
Available online http://www.academicjournals.org/JSPPR
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Full Length Research Paper

Effects of temperature and period of blanching on the pasting and functional properties of plantain (*Musa parasidiaca*) flour

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Accepted 25 July, 2011

The effect of temperature and period of blanching on the pasting and functional properties of the flour obtained from plantain (*Musa AAB*) blanched under three temperature regimes were studied. Plantain fruit fingers were washed, hand-peeled and manually sliced into cylindrical pieces of 2 mm thickness. Blanching was carried out on the sliced samples in hot water at 60, 80 and 100°C for varied periods of 5, 10 and 15 min and dried in the air oven at 65°C (24/h), while the un-blanched sample served as the control. Results showed that blanching temperature and time variation had significant effects ($P < 0.05$) on pasting and functional properties of the plantain flour. The peak viscosity ranged between (355.25 to 527.08 RVU), trough of (235.83 to 335.92 RVU), breakdown of (91.92 to 217.67 RVU), final viscosity of (302.75 to 434.92 RVU), setback of (64.58 to 103.08 RVU), peak time of (4.52 to 4.91 min) and pasting temperature of (81.55 to 83.23°C) across the blanching temperature and time chosen. The blanched samples were significantly different ($P > 0.05$) from each other and from the un-blanched control. However, varying the blanching time did not show any significant difference in water and oil absorption capacity for each temperature chosen compared to the control, the bulk density varied between (0.194 to 0.420 g/ml), emulsion capacity (17.86 to 41.12%) while the control was 39.84% which was significantly different from the other samples. Least gelation concentration varied between (2.0 to 6.0%). Samples blanched at 60°C for 5, 10 and 15 min were not significantly different from each other but were significantly higher than that of the control which was (2%). Results indicated that the blanched plantain flours could be utilized as substitutes for soya and wheat flours in complementary/weaning foods and also useful as an important consideration in the production of pastries. Blanched plantain flour will be useful as a better binder and meat extender than the unblanched plantain flour. Blanching at low blanching temperature produced a flour of low stability against retrogradation than those at high temperature.

Key words: Plantain, flour, blanching, functional and pasting properties.

INTRODUCTION

Plantain (*Musa parasidiaca*) is an important staple food in Central and West Africa (Stover and Simmonds, 1987) which along with bananas provide 60 million people with 25% of the calories (Wilson, 1987). Nigeria produces about 2.11 million metric tonnes annually (FAO, 2004). However, about 35 to 60% post harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing (Olorunda and Adelusola, 1997). When processed into flour, it is used traditionally for the preparation of gruel which is made by mixing the flour with appropriate quantities of boiling water to form a thick paste (Mepba et al., 2007). Pere-Sira (1997) had also indicated the use of plantain flour as a component of baby food. However studies have shown that plantain, like other fruits, is susceptible to browning when the pulp is sliced. The browning potential of various fruits and vegetables has been shown to be directly related to the ascorbic acid level, polyphenol

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Treatment	Plant material type	Code	Temperature of conservation (℃)	Time of blanching (mm)
		PB_{60-5}	60	5
A	Plantain blanched	PB_{60-10}	60	10
		PB_{60-15}	60	15
		PB_{80-5}	80	5
B	Plantain blanched	PB_{80-10}	80	10
		PB_{80-15}	80	15
		PB_{100-5}	100	5
C	Plantain blanched	PB_{100-10}	100	10
		PB_{100-15}	100	15
Control	Un-blanched plantain	UPB_{CO}	-	-

Table 1. Experimental design of the effect of blanching at 60, 80 and 100℃ for 5, 10 and 15 min on properties of flour from blanched and unblanched plantain (*Musa parasidiaca*).

oxidase activity (Golan et al., 1977). Therefore, dehydration methods such as hot-air blanching and osmo-dehydration are employed to remove water and limit enzymatic and non-enzymatic browning in foods. Processing of plantains into flour is limited as most plantain foods are eaten as boiled, fried or roasted (Tortoe et al., 2008). Essential in determining potential uses for plantain flour is the identification of its functional properties. Functional properties of plantain flour in baked products have being reported by Ogazi (1986) and Gwanfogbe et al. (1988).

Pasting properties is an important index in determining the cooking and baking qualities of flour. Studies have been conducted on the pasting properties of plantain soy flour mixes (Abioye et al., 2006). The important component of pasting properties of starch is associated with a cohesive paste and has been reported (Oduro et al., 2000) to be significantly present in domestic products such as pounded yam, which requires high setback, high viscosity and high paste stability.

Various studies have been carried out on the processing and utilization of plantain. Ukhum and Ukpebor (1991) determined the sensory evaluation and physico-chemical changes during storage of instant plantain flour. Onyejegbu and Olorunda (1995) studied the effects of processing conditions and packaging on the quality of plantain chips. Ogazi (1996) carried a lot of studies ranging from processing and utilization of plantain in various forms including complementary diets. Fagbemi (1999) studied the effect of blanching and ripening on functional properties of plantain (*Musa aab*) flour. He observed that blanching reduced the emulsion capacity and viscosity, while bulk density, water and oil absorption capacities were increased by blanching. Unripe plantain could be used as an emulsifier and thickener in a food system. He also observed that ripening had a negative effect on all the functional properties examined except the bulk density, and gelation property. However, more studies need to be carried out to determine the effect of different processing conditions on the various quality attributes of the plantain flour. The objectives of this study are therefore to determine the effect of varying the temperature and period of blanching on the pasting and the functional properties of plantain flour.

MATERIALS AND METHODS

Mature green and healthy plantain (*Musa*, AAB group) bunches were obtained from the International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, with acceptable appearance for consumption (Dadzie and Orhard, 1997). All reagents used were of analytical grade.

Preparation of plantain flour

The fruits were processed at green (unripe) stages which were subsequently de-fingered. The fingers were washed, hand-peeled and manually sliced into cylindrical pieces of 2 mm thickness. Blanching was carried out on the sliced samples in hot water at 60, 80 and 100℃. For each temperature chosen, the timing was varied for 5,10 and 15 min and dried in the air oven at 65℃ (24/h), using the unblanched sample as the control (Baiyeri and Ortiz, 2000). The dehydrated products were milled in a hammer mill to produce flour which passed through a 500 μm screen. The plantain flour obtained was packaged in polyethylene bags labeled and stored at room temperature for further analysis (Table 1).

Analysis

The samples were evaluated for functional and pasting properties. Functional properties such as water and oil absorptions, emulsion capacity were determined as described by Sathe et al. (1982), emulsion stability as described by Beuchat (1977). The bulk density was determined as described by Narayana and Narasinga (1984). The modified procedure of Coffman and Garcia (1977) was used to determine least gelation concentration, swelling power and solubility were determined by the methods of Leach et al. (1957).

The pasting properties of the samples were assessed in a rapid visco analyser (RVA-4) using the RVA general pasting method (Newport Scientific Pty Ltd, Warriewood, Australia). The sample was turned into slurry by mixing 3 g (14% moisture basis) with 25 ml of water inside the RVA test canister which was then lowered into the system (Newport Scientific, 1998). The slurry was heated from 50 to 95°C and cooled back to 50°C within 12 min, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. Parameters estimated were peak viscosity, setback viscosity, final viscosity, pasting temperature and time to reach peak viscosity. All the experiments were conducted in triplicates and the mean ± standard deviation were reported. Data were subjected to analysis of variance (ANOVA) and the means separated by Duncan's New Multiple Range test (DMRT) at a significance level of 0.05.

RESULTS AND DISCUSSION

Pasting properties

The pasting properties of starch are used in assessing the suitability of its application as functional ingredient in food and other industrial products. The most important pasting characteristic of granular starch dispersion is its amylographic viscosity (Aviara et al., 2010). Plantain flour forms paste when reconstituted with hot water, hence its amylographic viscosities are important in assessing the suitability of its application as functional ingredient in food and other industrial products (Aviara et al., 2010). When starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size. Over a critical temperature, which is characteristic of a particular starch, the starch undergoes an irreversible process known as gelatinization (Adebowale et al., 2008). When the temperature rises above the gelatinization temperature, the starch granules begin to swell and viscosity increases on shearing. The temperature at the onset of this rise in viscosity is referred to as the gelatinization or pasting temperature (Isikli and Karababa, 2005). The pasting temperature of the plantain flour samples ranged between 79.93 and 83.23°C for the blanched samples and 81.80°C for the control (Table 2). The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu et al., 2005), it can have implications for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998).

The peak time is a measure of the cooking time (Adebowale et al., 2005). This ranged between 4.53 to 4.91 min for the blanched samples and 4.52 min for the control sample. Peak viscosity, which is the maximum viscosity, developed during or soon after the heating portion of the pasting test (Newport Scientific, 1998), is lower for the blanched samples (355.25 to 527.08 RVU) and highest for the control sample (543.42 RVU). Peak viscosity is often correlated with the final product quality. It also provides an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon et al., 2004). Higher swelling index is indicative of higher peak viscosity while higher solubility as a result of starch degradation or dextrinization results in reduced paste viscosity (Shittu et al., 2001). These were corroborated by results of swelling power and solubility reported earlier. The hold period sometimes called shear thinning, holding strength, hot paste viscosity or trough due to the accompanied breakdown in viscosity is a period when the sample was subjected to a period of constant temperature (usually 95°C) and mechanical shear stress. It is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling (Newport Scientific, 1998). This ranged between 248.92 and 325.75 RVU for blanched sample at 100 and 60°C respectively, while the un-blanched control had a higher value of 325.75 RVU. This period is often associated with a breakdown in viscosity (Ragaee et al., 2006). It is an indication of breakdown or stability of the starch gel during cooking (Zaidhul et al., 2006). The lower the value the more stable is the starch gel. The breakdown is regarded as a measure of the degree of disintegration of granules or paste stability (Dengate, 1984; Newport Scientific, 1998).

The breakdown viscosities recorded by blanched samples were lower than that of the un-blanched control sample. They reduced from 217.67 RVU in the control to a range of 161.08 to 207.25 RVU in the samples blanched at 100 and 60°C respectively. The viscosity after cooling to 50°C represents the setback or viscosity of cooked paste. It is a stage where retrogradation or re-ordering of starch molecules occur. It is a tendency to become firmer with increasing resistance to enzymic attack. It also has effect on digestibility. Higher setback values are synonymous to reduced dough digestibility (Shittu et al., 2001) while lower setback during the cooling of the paste indicates lower tendency for retrogradation (Sandhu et al., 2007). The final viscosity was highest for the control gari (439.33 RVU), while it ranged between 302.75 and 414.92 RVU for the blanched samples. The extent of increase in viscosity on cooling to 50°C reflects the retrogradation tendency (Ragaee et al., 2006; Sandhu et al., 2007). The setback viscosity indicates the tendency of the dough to undergo retrogradation, a phenomenon that causes the dough to become firmer and increasingly resistant to enzyme attack (Ihekoronye and Ngoddy, 1985). It has a serious implication on the digestibility of the dough when consumed. The high setback value for the sample at low blanching temperature indicates that its paste would have a low stability against retrogradation (Mazurs et al., 1957) than those at high temperature.

Functional properties

The water absorption capacity (WAC) of all the treated

Table 2. Pasting properties of plantain flour blanched for 5, 10 and 15 min at 60, 80 and 100°C.

Sample	UPB_{CO}	PB_{60}			PB_{80}			PB_{100}		
		5	10	15	5	10	15	5	10	15
Peak viscosity(RVU)	543.42±0.20^{a}	527.08±0.04^{b}	511.92±0.01^{b}	445.67±0.04^{b}	434.58±0.17^{c}	414.08±0.56^{c}	403.58±0.30^{c}	422.0±0.04^{c}	410.0±0.56^{c}	355.25±0.17^{d}
Trough (RVU)	325.75±0.32^{a}	335.92±0.01^{a}	304.67±0.01^{b}	291.08±0.54^{b}	288.92±0.43^{c}	276.92±4.60^{c}	235.83±2.09^{d}	257.33±0.49^{d}	248.92±0.04^{d}	263.33±0.31^{c}
Breakdown (RVU)	217.67±0.51^{a}	191.16±0.04^{b}	207.25±0.02^{b}	154.59±0.51^{c}	145.66±0.60^{d}	137.16±5.16^{d}	167.75±2.39^{b}	164.67±0.45^{c}	161.08±0.52^{c}	91.92±0.14^{d}
Final viscosity (RVU)	409.33±0.10^{a}	434.92±0.01^{a}	407.75±0.03^{b}	374.92±0.05^{b}	353.50±1.25^{c}	366.50±0.21^{c}	302.75±0.07^{d}	343.75±0.39^{d}	320.42±0.10^{d}	355.92±0.40^{c}
Setback (RVU)	83.58±0.22^{b}	99.00±0.00^{a}	103.08±0.02^{a}	83.84.66±1.04^{b}	64.58±0.82^{c}	89.58±4.39^{b}	66.92±2.13^{c}	86.42±0.10^{b}	71.50±0.06^{c}	92.59±0.09^{a}
Peak time (min)	4.52±0.01^{b}	4.73±0.01^{a}	4.53±0.01^{b}	4.64±0.04^{b}	4.75±0.05^{a}	4.67±0.00^{a}	4.59±0.02^{b}	4.64±0.04^{b}	4.56±0.05^{b}	4.91±0.02^{a}
Pasting temperature(°C)	81.80±0.10^{ab}	82.65±0.00^{ab}	79.93±0.03^{c}	81.55±0.01^{b}	82.77±0.58^{a}	81.20±0.4^{b}	82.55±0.01^{b}	80.90±0.70^{c}	81.32±0.34^{ab}	83.23±0.03^{a}

Table 3. Functional properties of plantain flour blanched for 5, 10 and 15 min at 60, 80 and 100°C.

Sample	UPB_{CO}	PB_{60}			PB_{80}			PB_{100}		
		5	10	15	5	10	15	5	10	15
Water absorption capacity (%)	124.50±4.50^{a}	120.50±0.50^{b}	118.50±0.50^{b}	115.50±0.00^{b}	123.50±1.50^{a}	123.50±0.50^{a}	123.50±0.50^{a}	125.50±0.50^{a}	125.50±0.50^{a}	125.50±0.50^{a}
Oil absorption capacity (%)	108.50±4.50^{a}	115.50±0.50^{a}	111.50±0.50^{a}	109.00±1.0^{a}	112.50±0.50^{a}	112.50±0.50^{a}	111.50±0.50^{a}	110.50±0.50^{a}	112.50±0.50^{a}	111.50±0.50^{a}
Bulk density (g/ml)	0.420±0.07^{a}	0.249±0.02^{b}	0.219±0.08^{b}	0.290±0.02^{b}	0.182±0.05^{c}	0.164±0.08^{c}	0.140±0.01^{c}	0.172±0.03^{c}	0.159±0.07^{c}	0.140±0.03^{c}
Emulsion stability (%)	41.27±0.51^{a}	29.83±0.27^{b}	26.82±0.50^{b}	31.07±0.00^{b}	24.58±1.41^{c}	20.04±0.29^{c}	30.23±0.35^{b}	18.48±0.09^{d}	12.03±0.07^{d}	20.25±0.10^{c}
Emulsion capacity (%)	39.84±0.19^{a}	41.12±0.28^{a}	30.45±0.72^{c}	36.68±0.37^{b}	30.46±0.62^{c}	25.00±0.11^{c}	36.19±0.32^{b}	27.03±0.12^{c}	17.86±0.17^{d}	24.14±0.18^{c}
Swelling power (%)	48.09±0.23^{a}	36.04±0.18^{c}	39.98±0.12^{b}	40.03±0.08^{b}	30.95±0.07^{d}	28.47±2.61^{d}	35.98±0.07^{c}	39.80±1.24^{b}	38.19±0.33^{b}	35.16±0.21^{c}
Solubility (%)	5.89±0.33^{a}	4.24±0.03^{b}	3.77±0.04^{d}	3.47±0.05^{d}	4.69±0.09^{b}	4.59±0.07^{b}	4.38±0.09^{b}	4.02±0.07^{c}	4.14±0.07^{c}	4.31±0.06^{b}
Least gelation concentration (%)	2.00±0.00^{c}	6.00±0.00^{a}	6.00±0.00^{a}	6.00±0.00^{a}	4.00±0.00^{b}	4.00±0.00^{b}	6.00±0.00^{a}	4.00±0.00^{b}	6.00±0.00^{a}	6.00±0.00^{a}

samples ranged between (118.50 to 125.50%) across the blanching temperature and time (Table 3). There were no significant differences in the control and blanched samples ($P > 0.05$) except for samples blanched with 60°C which recorded lower values of 115.5 to 120.50°C. This is contrary to the finding of Fagbemi (1999) who observed that water absorption capacity could be enhanced by blanching. However, the WAC values are higher than 36 and 85% reported for fluted pumpkin seed flour, but lower than the values of 100% for gourd seed flours (Olaofe et al., 1994) many of oil seeds defatted flours (100 to 260%) (Ige et al., 1984), 120% for lupin seed flour, 130% for soy flour, 138% for pigeon pea (Oshodi and Ekperigin, 1989), and 157% for calabash seed flour (Olaofe et al., 2009) and 610 and 670% for full fat and defatted *Dioclea reflexa* seed flour respectively (Akinyede et al., 2005). The comparatively higher water absorption capacity of 125% recorded for the samples blanched at 100°C is an indication of its use in composite flours for bread making. WAC is considered critical in viscous foods such as soups and gravies; thus, the flours may find use as functional ingredients in soups, gravies and baked products (Akinyede et al., 2005). The oil absorption capacity (OAC) of the samples ranged between (108.50 to 115.50%) while the treated samples were not significantly ($P > 0.05$) different from the unblanched/control (108.50%). The OAC were however higher than 89.7% reported for pigeon pea (Oshodi and Ekperigin, 1989), jack bean (105.6%), gourd seed flour (96%) (Olaofe et al., 1994) but lower than the values of 140, 193, 142, and 142%, reported for chickpea, soy, yam bean flours, fluted pumpkin seed flour respectively (Ige et al., 1984; Oshodi and Ekperingin, 1989; Oshodi et al., 1999; According to Fagbemi (1999), good oil absorption capacity of flour samples suggest that they may be useful in food preparations that involve oil mixing like in bakery products, where oil is an important ingredient. The water/fat binding capacity of proteins is an index of its ability to absorb and retain oil, which in turn influences the texture and mouth feel of food products like ground meat formulations, doughnuts, pancakes, baked goods and soups.

The seed flours may thus be used to replace some legumes and oil seeds as thickeners used in some liquid and semi liquid foods (Akinyede et al., 2005). This is an indication that the flours can act as flavour retainer and be used to improve the mouth feels of food. The bulk-density of the samples reduced with blanching from 0.420 g/ml for the control sample to a range of values between 0.140 and 0.420 g/ml for the blanched samples. The bulk densities of the blanched samples at 60°C for 5, 10 and 15 min were significantly higher than other samples blanched at 80 and 100°C. This is contrary to a report made by Tagogoe (1994) and Fagbemi (1999) which showed that bulk density increased as a result of blanching/heat treatment prior to drying. The reduction in the bulk densities in samples blanched at 80 and 100°C will be an advantage in the bulk storage and transportation of the flour. The emulsion capacity (EC) and stability of the blanched samples were generally lower than the unblanched/control (39.84 and 41.27%) respectively. As blanching temperature and time increased, emulsion capacity and stability of the samples reduced. This is consistent with the observation of Fagbemi (1999) which could be attributed to the heat of blanching. The EC of the blanched and unblanched/control flours ranging from 17.86 to 41.12%, are however higher than those of soya bean (15.0%), breadnut flour (18%), 8.1 and wheat flours (7 to 11%) (Lin et al., 1974) and calabash seed flour (23.2%) (Olaofe et al., 2009) suggesting that the blanched and unblanched/control plantain flours could be utilized as substitutes for soya and wheat flours in complementary/ weaning foods. The values are comparable with those of *Pachira glabra* (35.5%) and *Afzelia africana* seeds (41.5%) (Ogunlade et al., 2011), pigeon pea (49.1%) and sunflower flours (75.1%) (Adeyeye et al., 1994; Oshodi and Ekperijin, 1989; Oshodi et al., 1999). EC is an important consideration in the production of pastries, coffee whiteners and frozen desserts. Emulsion capacity denotes the maximum amount of oil that can be emulsified by protein dispersion, whereas emulsion stability denotes the ability of an emulsion with a certain composition to remain unchanged (Enujuigha et al., 2003).

Blanched and unblanched/control flours may thus be useful in such food formulations (Akinyede et al., 2005). The emulsion stability values (50.0 ± 0.0% and 51.00 ± 0.0%) were higher than 11.5 and 29.5% for gourd seed and yellow melon respectively (Ogungbenle, 2006). The swelling power (SP) of the blanched samples ranging between 28.47 and 40.03% were generally lower than that of the unblanched/control (48.09%) while the solubility ranging from 3.47 to 4.69% were also lower than that of the control (5.89%). Increase in blanching temperature and time had a significant ($P < 0.05$) decrease on the swelling power on the samples. The least gelation concentration (LGC) of the unblanched/ control (2.00%) was significantly lower ($P < 0.05$) than those of the blanched samples which ranged from 4.0 to 6.0%. Blanching increased the least gelation concentration implying that the flour of the blanched plantain will act as a better binder. The values were lower than those reported for cowpea (10 to 14%), great northern bean (10%) and lupine seed flours (14%) The ability of seed flours to form gel is desirable in the preparation of extended meat products (Akinyede et al., 2005).

Conclusion

This study has shown that blanching caused a reduction in emulsion capacity. However, their higher values than soy and wheat flours suggests that the plantain flours could be utilized as substitutes for soya and wheat flours in complementary/weaning foods and also useful as an important consideration in the production of pastries, coffee whiteners and frozen desserts. Blanching increased the least gelation concentration, implying that the flour of the blanched plantain is a better binder and more useful as a meat extender than the unblanched plantain flour. The high setback value for the sample at low blanching temperature indicates that its paste would have a low stability against retrogradation than those at high temperature. The lower breakdown viscosity recorded by blanched samples over the un-blanched control sample was an indication of paste stability of the starch gel during cooking.

REFERENCES

Abioye VF, Ade-Omowaye BIO, Adesigbin MK (2006). Effect of Soy Flour Fractions on some Functional and Physicochemical Properties of Plantain Flour In: (O.A. T. Ebuehi, ed), pp. 142-143.

Adebowale AA, Sanni LO, Onitilo MO (2008). Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. Afr. J. Food Sci., 2: 077-082

Adebowale AA, Sanni LO, Awonorin SO (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. Food Sci. Technol. Int., 11(5): 373-382.

Adeyeye EI, Oshodi AA, Ipinmoroti KO (1994). Functional properties of some varieties of African yam bean (*Sphenostylis sternocarpa*) flour II. Int. J. Food Sci., Nutr., 45: 1-12.

Akinyede AI, Amoo IA, Eleyinmi AF (2005). Chemical and functional properties of full fat and defatted *Dioclea reflexa* seed flours J. Food, Agricul. Environ., 3 (2): 112-115. www.world-food.net.

Aviara NA, Igbeka JC, Nwokocha LM (2010). Physicochemical properties of sorghum (sorghum bicolor l. Moench) starch as affected by drying temperature. Agric. Eng. Int. CIGR J. Open access at http://www.cigrjournal.org 12:2 85

Baiyeri KP, Ortiz R (2000). Effect of Nitrogen Fertilization on Mineral Concentration in Plantain (Musa species AAB) Fruit Peel and Pulp at Unripe and Ripe Stages. Plant Product Res. J., 5: 38-43.

Beuchat LR (1997) Functional and Electrophoretic Characteristics of Succinylated Peanut Flour. J. Agric. Food Chem., 25: 258-261.

Coffman C, Garcia VV (1977). Functional Properties of Protein Isolate from Mung Bean Flour. J. Food Tech., 12: 473-484.

Dadzie BK, Orchard JE (1997): Routine Post-Harvest Screening of Banana / Plantain Hybrids: Criteria and Methods. INIBAP Technical Guidelines.

Dengate HN (1984). Swelling, pasting, and gelling of wheat starch. In: Pomeranz Y (Ed) Adv. Cereal Sci. Technol. AACC, USA, pp. 49-82.

Enujuigha VN, Badejo AA, Iyiola SO, Oluwamukomi MO (2003). Effect of germination on the nutritional and functional properties of African oil bean (*Penthaclethra macrophylla* Benth) seed flour. J. Food, Agricul. Environ., 1 (3&4): 72-75.

Fagbemi TN (1999). Effect of Blanching and Ripening on Functional Properties of Plantain (Musa aab) Flour. Foods Hum. Nutr., 54: 261-269.

FAO (Food and Agriculture Organization) (2004). Statistics Series No 95 FAO, Rome.

Golan A, Kahn V, Saduski AY (1977). Relationship between Polyphenols and Browning in Avocado Mesocarp-Comparison between the Fuerte and Lerman Cultivars. J. Agric. Food Chem., 25: 1253-1259.

Gwanfogbe PN, Cherry JP, Simmons JG, James C (1988) Functionality and Nutritive Value of Composite Plantain (Musa paradisiaca) Flours. Trop. Sci., 28: 51-66.

Ige MM, Ogunsua AO, Oke OL (1984). Functional properties of the proteins of some Nigerian oil seed, conophor seeds and three varieties of melon seeds. J. Agric. Food Chem., 32: 822-825

Ihekoronye AI, Ngoddy PO (1985). Browning reaction. In: Integrated Food Science and Technology for the Tropics. Macmillan Education Ltd, London, pp. 224-229.

Isikli ND, Karababa EA (2005). Rheological characterization of fenugreek paste (cemen). J. Food Eng., 69:185-190.

Leach HW, McCowan LD, Schoch TJ (1957). Structure of the Starch Granule: Swelling Power and Solubility Patterns of Different Starches. Cereal Chem., 36: 534-544.

Lin MJY, Humbert ES, Sosulski FW (1974). Certain functional properties of sunflower meal products. J. Food Sci., 39: 368-370.

Maziya-Dixon B, Dixon AGO, Adebowale AA (2004). Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB Symposium, 31 October – 5 November 2004, Whitesands Hotel, Mombasa, Kenya.

Mazurs EG, Schoch TJ, Kite FE (1957). Graphical analysis of the brabender viscosity curves of various starches. Cereal Chem., 34(3): 141-153

Mepba HD, Eboh L, Nwaojigwa SU (2007). Chemical Composition, Functional and Baking Properties of Wheat – Plantain Composite Flours. Afr. J. Food Agric, Nutr. Dev., 7(1): 4-5.

Narayana K, Narasinga Rao MS (1984). Effects of partial proteolysis on the functional properties of winged bean (*Phosphorcapus tetragonolobus*) flour. J. Food Sci., 49: 944-947.

Newport Scientific (1998). Applications manual for the Rapid Visco Analyzer using thermocline for windows. Newport Scientific Pty Ltd., 1/2 Apollo Street, Warriewood NSW 2102, Australia, pp. 2-26.

Oduro I, Ellis W, Dziedzoave N and Nimako-Yeboah K (2000). Quality of gari from selected processing zones in Ghana. Food Control, 11: 297-303.

Ogazi PO (1986). Quality Assessment of Plantain Fruits for Dehydration. Nig. Food J., 4(1): 125-130.

Ogazi PO (1996). Plantain: production, processing and utilization. Paman and Associates Limited, Uku-Okigwe, p. 305.

Ogungbenle HN (2006). Chemical composition, functional properties and amino acid composition of some edible seeds. La Rivista Italiana Delle Sostanze Marzo, 73: 81-86.

Ogunlade I, Ilugbiyin A, Osasona AI (2011). A comparative study of proximate composition, antinutrient composition and functional properties of Pachira glabra and Afzelia africana seed flours. Afr. J. Food Sci., 5(1): 32-35

Olaofe O, Adeyemi FO and Adediran GO (1994). Amino acid, chemical composition and functional properties of some oil seeds. J. Agric. Food Chem., 42(4): 879-881.

Olaofe O, Ekuagbere AO, Ogunlade I (2009). Chemical, amino acid composition and functional properties of calabash seed's kernel. Bull. Pure Appl. Sci., 28(1- 2): 13-24.

Olorunda AO, Adelusola MA (1997). Screening of Plantain / Banana Cultivars for Import, Storage and Processing Characteristics. Paper Presented at the International Symposium on Genetic Improvement of Bananas for Resistance to Disease and Pests 7 – 9th September, (IRAD, Montpellier, France).

Onyejegbu CA, Olorunda AO (1995). Effects of raw materials, processing conditions and packaging on the quality of plantain chips. J. Sci. Food Agric., 68: 279-283.

Oshodi AA, Ekperijin NM (1989). Functional properties of pigeon pea flour (Cajanus cajan) Food Chem., 34: 187-191.

Oshodi AA, Ogungbenle HN, Oladimeji MC (1999). Chemical composition, nutritionally valuable minerals and functional properties of benniseed (*Sesamum radiation*), pearl millet (*Pennisetum typhoides*) and quinoa (*Chenopodium quinoa*) flours. Int. J. Food Sci. Nutr., 50: 325-331.

Pere-Sira E (1997). Characterization of Starch Isolated from Plantain (*Musa paradisiacal normalis*) Starch, 49: 45-49.

Ragaee S, Abdel-Aal EM (2006). Pasting properties of starch and protein in selected cereals and quality of their food products. Food Chem., 95: 9-18.

Ramteke RS, Eipeson WE (2000). Predehydration Steaming Changes Physicochemical Properties of Unripe Banana Flour. Dept. of Food Sci. and Tech., Makerere University Kampala Uganda.

Sandhu KS, Singh N, Malhi NS (2005). Physicochemical and thermal properties of starches separated from corn produced from crosses of two germ pools. Food Chem., 99: 541-548.

Sandhu KS, Singh N, Malhi NS (2007). Some properties of corn grains and their flours I: Physicochemical, functional and chapati-making properties of flours. Food Chem., 101: 938-946.

Sathe SK, Desphande SS, Salunhkhe DK (1982). Functional properties of lupin seed (Lupinus mutabilis) proteins and protein concentrates. J. Food Sci., 47: 491-497.

Shittu TA, Lasekan OO, Sanni LO, Oladosu MO (2001). The effect of drying methods on the functional and sensory characteristics of pukuru-a fermented cassava product. ASSET-An Intern. J., 1(2): 9-16.

Stover RH, Simmonds NW (1987). Bananas: Tropical Agriculture Series (3rd Edition) Inc. New York

Tagodoe A (1994). Functional Properties of Raw and Precooked Taro Colocasia Esculenta Flour. Int. J. Food Sci. Tech., 29: 457-482.

Tortoe CT, Paa – Nii TJ, Apollonius IN (2008). Effects of Osmo-Dehydration, Blanching and Semi – Ripening on the Viscoelastic, Water Activity and Colorimetry Properties of Flour from Three Cultivars of Plantain (Musa AAB). CSIR – Food Research Institute, Accra, Ghana.

Ukhum ME, Ukpebor IE (1991). Production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. Food Chem., 42: 287-299.

Wilson CF (1987). Status of Bananas and Plantains in West Africa in Bananas and Plantain Breeding Strategies Proceedings of International Workshop on Plantain and Banana. Australian Council for International Research.

Zaidhul ISM, Hiroaki Y, Sun-Ju K, Naoto H and Takahiro N (2006). RVA study of mixtures of wheat flour and potato starches with different phosphorus contents. Food Chemistrydoi:10.1016/j.foodchem.2006.06.056.