

Effect of Different Processing Methods on Proximate, Functional and Pasting Properties of Plantain Flour

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ABSTRACT--- *The effect of different processing methods on functional and physico-chemical properties of plantain flour was investigated. Flours were prepared from unripe matured plantain Musa spp. (Agbagba variety) which was subjected to different processing methods of blanching, natural fermentation, lacto-fermentation and raw unripe plantain which serves as the control. The natural and lacto-fermented plantain flakes was allowed to take place for 48 h while the blanched plantain flakes was blanched at 85⁰C for 5min before they were oven dried 60⁰C for 72h and then milled into flour. The flours are examined for their proximate composition, functional properties, pasting characteristics and sensory evaluation of gruels made from each plantain flour sample. The sensory evaluation shows there is significant difference between the control and plantain flour samples in terms of colour and texture, the overall acceptability indicate the control is ranked the highest while the lacto-fermented flour gruels was ranked the least, this maybe due to the fact that lacto-fermented plantain flour is a new modification of plantain flour. The solubility of the flour samples ranged between 8.47-12.17%, least gelation 4.0-6.0%, water absorption capacity 146.67-180.00%, bulk density (loosed) 0.35-0.36g/ml, bulk density (packed) 0.56-0.59g/ml, titratable acidity 0.21-0.55 % and pH ranges between 7.05-7.28. Proximate analysis showed that the samples were low in moisture, crude fat, ash and crude fibre but high in carbohydrate and slightly high in protein. Blanching improves least gelation and bulk density which implies that the blanched plantain flour will be a good binder and more useful as a meat extender, natural fermentation also improves the breakdown viscosity at 37.00RVU and lower breakdown viscosity indicate paste stability of the starch gel during cooking, lacto-fermentation improves gelation and WAC but it has low effect on the setback during pasting analysis.*

Keywords---- Plantain flour, blanching, fermentation, proximate, pasting, functional and sensory properties.

1. INTRODUCTION

Plantain and other cooking bananas are staple food grown throughout the tropics and they constitute a major source of carbohydrate for millions of people in Africa, the Caribbean, Latin America, Asia and the Pacific (INIBAP, 2001). Due to the perishable nature of the fruits (Adebesin *et al*, 2009), the rate of the post-harvest losses of plantain varies from one country to another according to the organization of market chains and modes of consumption. It is a perennial crop that grows well in a wide range of environments and belongs to the family of Musaceae and has been crops of extra-ordinary significance to human societies. Presently, plantain rank as the fourth most important food crop in the world after rice, wheat and maize and are used as food, beverages, fermentable sugars, medicines, flavouring and cooked foods (Nelson *et al* 2006, Phillip *et al* 2009). Half-ripe plantain is usually processed into plantain flour by slicing the plantain and sun drying for some days and cooked into sticky paste delicacy “*Amala ogede*” (Yoruba) served with vegetable soup. Half-ripe plantain can also be boiled, fried, processed into chips or pounded to plantain pastry and eaten with soups, sauce or vegetables. Ripe plantain flour has been used in making bread, biscuits and instant flour (Ngalani and Crouzet, 1995). Plantain is also processed into ‘*dodo*’ (fried sliced ripe plantain pulp), chips (fried half-ripe pulp) (Akinwumi, 1999) and in addition it can also be processed into food/foodstuffs such as breakfast cereals, baby complementary foods (Folayan and Bifarin, 2011). The term fermentation has gained several novel meanings while retaining the old ones. Fermentation has been routinely applied to any process employing micro-organisms for production of useful commodities including industrial products. However, biochemically, fermentation stands for a process that leads to generation of energy from organic compound under anaerobic conditions. With regards to physiology or metabolism, fermentation refers to an energy generating process where organic compound acts as both electron donor and acceptor under anaerobic conditions. In context of industrial microbiology or biotechnology, fermentation is defined as the process by which large quantities of living cells are grown under aerobic and anaerobic conditions for producing some useful commodity (Naven, 2010). Blanching is a unit operation prior to freezing, canning or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes, modifying texture, preserving

color, flavor, nutritional value and removing trapped air. Most vegetables are blanched prior to freezing to inactivate enzymes that cause the development of off-flavors and off-colors during frozen storage (Downing, 2003).

Plantain is often sundried and milled into flour and not always blanched or fermented thus the objective of this study was to explore the impact of fermentation and blanching on physic-chemical and functional properties of plantain flour.

2. MATERIALS AND METHODS

Materials

The plantain (*Agbagba* variety) used for this research is of *Musa* spp and freshly harvested after attaining full maturity and was obtained from a local farm in Lagos State.

Methods

The matured freshly cut green plantain were rinsed with tap water, peeled, washed and sliced into 10mm cubes. Some of the plantain slices were then blanched by method described by Baiyeri and Ortiz (2000) while the other plantain slices were naturally fermented and lacto-fermented using the method described by Sally and Mary (1999) with little modifications.

Analytical determination

Proximate composition: protein, fat, minerals, crude fibre, moisture and carbohydrates contents were determined using (AOAC, 2004) method.

Functional properties: Water Absorption Capacity and Water Absorption Index were determined using the method of Wang and Kinsella (1976). Bulk density was determined using the method of Wang and Kinsella (1976). Swelling capacity was determined using the method of Ukpabi and Ndimele (1990). The pH of the flour samples were determined by the method of Eganet *et al.*, 1981 and titratable acidity was determined by the method of AOAC, 2000.

Determination of pasting properties: Pasting properties were determined with a Rapid Visco Analyzer (RVA) (Newport Scientific RVA Super 3). An aliquot 3grammes of sample was weighed in a vessel; 25ml of distilled water was dispensed into a new test canister. The sample was then transferred into the water surface in the canister. The paddle was placed into the canister and the blade vigorously jogged through the sample up and down ten times. The test proceeded and terminated automatically. The slurry was heated from 50 to 95°C and cools back to 50°C within 12min, rotating the can at a speed of 160rpm with continuous stirring of the content with a plastic paddle. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown value, pasting temperature and time to reach peak viscosity.

Sensory evaluation: Paste (gruel) was prepared from each of the composite flour. The pastes were kept separately in thermos flask for sensory evaluation with 20 untrained panelists drawn from Yoruba ethnic group among the staff and students of Department of Food Technology, Yaba College of Technology. They evaluated the samples using a nine point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked) (Watts *et al.*, 1989). The five pastes were coded appropriately in the hedonic scale. Each judge was given six white plastic cups and teaspoon for use in the sensory evaluation. The judges were provided with clean water to rinse their mouth in between testing of the porridges to avoid carry over effect. Each panelist evaluated the paste for color, flavour, texture, taste and overall acceptability.

Data analysis: Proximate analysis was carried out in three triplicates while pasting properties was in duplicate. The data were subjected to Analysis of Variance (ANOVA) ($p < 0.05$). Means with significant differences were separated by Turkey test using SPSS 11.0 software.

3. RESULTS AND DISCUSSION

Proximate composition of plantain flour

The proximate composition plantain flour samples subjected to different processing methods is presented on Table 1. The proximate analysis showed that all the samples were within the normal moisture contents of dried food (flour blends). According to these results there are significant differences ($p < 0.05$) in the moisture content of the four formulations. It was observed that there is no significant difference in the moisture content of the control and the processed plantain flour samples which varied between 8.63–9.03%. The low moisture observed for the five formulations is a good indicator of their potential to have longer shelf life. This is in line with the findings of Vincent, 2002. It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content. For is this reason, a water content of 10% is generally specified for flours and other related products. It should be pointed out that when these products are allowed to equilibrate for periods of more than oneweek at 60% relative

humidity and at room temperature (25 to 27°C), moisture content might increase. The low moisture content of the control and plantain flour samples compare favourably with the recommended standard of SON (2007) which indicate that moisture content of flour should be below 10% moisture level which is recommended for safe keeping of flour samples. The crude protein content obtained was high in the plantain flour sample subjected to blanching (T₂) at 3.53% and also the control (T₀) at 4.03% while the protein content in the plantain flour samples subjected to natural fermentation (T₁) and lacto-fermentation (T₃) was at decrease at the range of 3.30-3.13%. The crude protein obtained is comparatively higher than those recorded in literature for some other musa spp. Oduro *et al.* (2006) reported 1.09% for cooking banana while Onwuka and Onwuka (2005) reported 2.8% for false horn. The lower level of fat in the control and other plantain flour samples range from 1.47-1.73%, this gives a higher probability of a longer shelf life in terms of the onset of rancidity (Ihekoronye and Ngoddy, 1985). There is no significant difference in the ash content of the plantain flour samples as compared with the control (T₀) which ranges from 2.80-3.23%. The control recorded the highest crude fibre 1.47% while there is no significant difference in the crude fibre of the plantain flour samples which are in the range of 1.23%, 1.33% and 1.13% in natural fermented plantain flour, blanched plantain flour and lacto-fermented plantain flour respectively. The carbohydrate was highest in the plantain flour samples at range 82.27% in natural fermented plantain flour, 81.63% in the blanched plantain flour and 82.40% in the lacto-fermented plantain flour. It is observed that there is no significant difference in the carbohydrate content between these plantain flour samples as compared to the control (T₀) which recorded the lowest carbohydrate content at range 80.93%.

Table 1: Proximate Composition of Plantain Flour

Samples	Moisture %	Protein %	Crude fat %	Ash %	Crude fibre %	Carbohydrate %
T ₁	8.93 ^a ± 0.15	3.30 ^a ± 0.10	1.47 ^a ± 0.06	2.80 ^a ±0.10	1.23 ^a ± 0.06	82.27 ^a ± 0.31
T ₂	9.03 ^a ± 0.15	3.53 ^b ± 0.06	1.50 ^a ± 0.10	2.97 ^a ±0.06	1.33 ^a ± 0.12	81.63 ^a ± 0.06
T ₃	8.73 ^a ± 0.15	3.13 ^a ± 0.06	1.47 ^a ± 0.06	3.13 ^a ±0.15	1.13 ^a ± 0.06	82.40 ^a ± 0.1780.93 ^b ±
T ₀	8.63 ^a ± 0.12	4.03 ^b ± 0.12	1.73 ^a ± 0.15	3.23 ^a ±0.15	1.47 ^b ± 0.06	0.3

Mean ± standard deviation for 3 determinations. Means followed by different superscript within the same column are significantly different (P≤0.05) T₀: Control, T₁: Natural fermentation, T₂: Blanching, T₃: Lacto fermentation

Functional properties of plantain flour

The physico- chemical properties of plantain flour is represented on table 2. There is no significant difference in bulk density (p≥0.05) between the control and other plantain flour samples which varied between 0.35–0.36g/ml for loosed bulk density and 0.56-0.59g/ml for packed bulk density. The reduction in the bulk density in the plantain flour samples will be an advantage in the bulk storage and transportation of the flour. The consistent bulk density is in agreement with the report of Okaka *et al* (1997) which suggested that bulk density of flour is not affected by factors such as blanching and temperature but is affected by factors such as particle size. Bulk density gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding (Padmashree *et al.*, 1987). The bulk density is related to particle size reduction which is evidence on the milling of the product. Also bulk density is an indication of porosity of a product which influence packaging design and could be used to determine the type of packaging material required (Iwe and Onadipe, 2001).

The water absorption capacity was significantly different (p≤0.05) in the control and the plantain flour samples but the control has the highest value of 180.00% of water absorption capacity and the lacto-fermented plantain flour sample recorded the lowest value 146.67% while the natural fermented and blanched plantain flour samples has the value 165.00 and 68.33% respectively. The increase in water absorption capacity implies high digestibility of the starch. Its characteristics represent the ability of the product to associate with water under condition where it is limiting in order to improve handling (Giami and Bekebian, 1992). Water binding capacity is a useful indication of whether flour or isolates can be incorporated into aqueous food formulations especially those involving dough handling (Okorie and Bello, 1988; Giami, 1993). The higher water absorption capacity results obtained suggest that plantain flours could be useful in food systems such as bakery products which require hydration to improve handling characteristics. The high water absorption capacity would be useful in bakery products where hydration to improve handling is desired, the water absorption capacity of the processed flours reported fell within the range reported for other flours such as the work reported by Lin *et al* (1974) for water absorption of soy flour (130%) and 227.3% and 196.1% respectively for two commercial soy protein concentrates namely, isopro and promo soy. There was significant difference (p≤0.05) observed in the solubility of the plantain flour samples and control. The control has the lowest solubility value 8.47% while the lacto-fermented plantain flour sample has the highest value 12.17%. The blanched and natural fermented plantain flour solubility value ranges from 9.27-10.07%. The low solubility observed could be attributed to the inability of hydrogen bonds to continue to be disrupted when the aqueous suspension of flour is raised above its gelatinization range so that water molecules can become attached to the liberated hydroxyl groups (Rickard, 1991). There is no significant difference in the least gelation

of the control, natural fermented and blanched plantain flour which they recorded 4.00% while the lacto-fermented recorded the highest least gelation at 6.00%. The pH value of a substance refers to its level of alkalinity or acidity. The pH result shows that there is no significant difference in the pH value of the control and the plantain flour samples, the pH value ranges from 7.05–7.28 which are neutral values and indicate alkalinity. Emperatriz *et al* (2008) reported values in the range of 4.6-6.1 when plantain flours were produced from different dehydration procedures. Dadzie (1998) reported values within the range of 6.0-6.5, deviations from reported values could be attributed to variations in temperature and pre-treatment. The titratable acidity shows there is significant difference ($p \geq 0.05$) between the control and the plantain flour samples. The lacto-fermented plantain flour sample recorded the highest 0.55% while control recorded the lowest 0.21% the blanched and natural fermented plantain flour sample range 0.32-0.36%.

Table 2: Functional properties of plantain flour

Sample	Solubility %	LG %	WAC %	Wettability %	BD (loosed) g/ml	BD (packed) g/ml	TTA (%)	pH
T ₁	10.07 ^a ±0.2	4.00 ^a ±0.1	165.00 ^a ±0.0	7.43 ^a ±0.1	0.35 ^a ±0.0	0.57 ^a ± 0.0	0.36 ^a ±0.1	7.20 ^a ±0.4
T ₂	9.27 ^b ±0.2	4.00 ^a ±0.1	168.33 ^b ±2.0	7.67 ^b ± 0.3	0.36 ^a ±0.0	0.58 ^a ± 0.0	0.32 ^b ±0.0	7.05 ^a ±0.1
T ₃	12.17 ^c ±0.2	6.00 ^b ±0.1	146.67 ^c ±2.9	6.73 ^c ±0.2	0.35 ^a ±0.0	0.56 ^a ± 0.0	0.55 ^c ±0.1	7.28 ^a ±0.5
T ₀	8.47 ^{ab} ±0.2	4.00 ^a ±0.1	180.00 ^d ±0.0	9.13 ^d ± 0.2	0.36 ^a ±0.0	0.59 ^a ± 0.0	0.21 ^d ±0.1	7.15 ^a ±0.3

Mean ± standard deviation for 3 determinations except for pH which is in duplicate. Means followed by different superscript within the same column are significantly different ($P \leq 0.05$) T₀: Control, T₁: Natural fermentation, T₂: Blanching, T₃: Lacto-fermentation, LG: Least gelation, WAC: water absorption capacity, BD: Bulk density

Pasting Characteristics of plantain flour

The pasting property of plantain flour samples compared with the control is shown in table 3.

Pasting characteristics is largely depended on amylase to amylopectin ratio of the starch (Sanni *et al.*, 1996). This indicates that the carbohydrate components of the flour samples will not breakdown until it is properly cooked and peak viscosity was reported to be important to the user in order to obtain a useable starch paste (Adeyemi, 1989). When starch-based foods are heated in an aqueous environment, they undergo series of changes known as gelatinization and pasting. These are two of the most important properties that influence quality and aesthetic considerations in the food industry, since they affect texture and digestibility as well as the end use of starchy foods (Adebowale *et al.*, 2005). The pasting properties are important as it is used in predicting the behaviour of porridge during and after cooking. Pasting temperature is a measure of the minimum temperature required to cook a given food sample and also gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable viscosity is measured and an index characterized by initial change due to the swelling of starch, it can have implications for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998). Pasting temperature has been reported to relate to water binding capacity, a higher pasting temperature implies higher water binding capacity property of starch due to high degree of association between starch granules (Kulkani *et al.*, 1991). The pasting temperature of the plantain flour samples ranges from 84.00-84.88°C and the control is 82.70°C which recorded the lowest pasting temperature. The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu *et al.*, 2007). The pasting temperature of the plantain flour is lower than the boiling temperature; hence the flour can form a paste in hot water below boiling point. This means at a commercial level, there is a remarkable cost saving. The peak time is a measure of the cooking time (Adebowale *et al.*, 2005), the blanched plantain flour sample (T₂) and control (T₀) has the lowest peak time at 5.23min and 4.90min respectively while the natural fermented plantain flour sample recorded 7.00min and the lacto-fermented plantain flour sample has the highest peak time at 8.20min. Peak viscosity which is the maximum viscosity developed during or soon after the heating portion of the pasting test is lowered. Peak viscosity is the ability of starch to swell freely before their physical breakdown (Sanni *et al.*, 2004). The natural fermented plantain flour sample (T₁) recorded the lowest peak viscosity at 1.333RVU and highest in the control (T₀) at 5150.50RVU. 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 *et al.*, 2004). The hold period sometimes called shear thinning is a period when the sample is subjected to a period of constant temperature (usually 95°C). It measures the ability of paste to withstand breakdown during cooling (Newport scientific, 1998). The control (T₀) has the highest value of the trough or hold period 3309.00RVU while the natural fermented plantain flour sample (T₁) has the lowest value 854.50RVU. The lacto-fermented (T₃) and blanched (T₂) plantain flour samples ranges between 938.50-2062.50RVU respectively. This period is an indication of breakdown or stability of the starch gel during cooking. The lower the value, the more stable is the starch gel. The breakdown value is regarded as a measure of the degree of disintegration of granules or paste stability (Newport scientific, 1998). Breakdown is a measure of susceptibility of cooked starch granules to disintegration and has been reported by Beta *et al.* (2000) to affect the stability of the flour products. A low breakdown

value suggests that they are more stable under hot condition. The breakdown viscosities of the plantain flour is high in the control and blanched plantain flour sample at 1857.00-512.00RVU and it is low in natural fermented and lacto-fermented plantain flour samples at 37.00-47.00RVU. The viscosity after cooling to 50°C represents the setback or viscosity of cooked paste. The control recorded the highest setback value 1841.50RVU, the blanched plantain flour sample has the lowest setback value 461.50RVU while setback values of the natural and lacto-fermented plantain flour samples ranges between 478.50-598.00RVU.

Table 3: Pasting Characteristics of processed plantain flour

Samples	Peak viscosity	Trough	Breakdown value	Final viscosity	Setback	Peak time	Pasting temp
T ₃	968.50 ^d ±3.23	938.50 ^d ±3.23	47.00 ^d ±0.00	1533.00 ^d ± 4.8	598.00 ^d ±1.4	8.20 ^d ±0.0	84.88 ^d ±0.4
T ₂	2574.5 ^a ±9.23	2062.50 ^a ±8.32	512.00 ^a ±1.3	2524.00 ^a ± 2.3	461.50 ^a ±6.1	5.23 ^a ±0.5	84.00 ^a ±0.0
T ₁	891.50 ^b ±3.23	854.50 ^b ±3.23	37.00 ^b ±0.0	1333.00 ^b ± 4.3	478.50 ^b ±1.5	7.00 ^b ±0.0	84.85 ^b ±0.7
T ₀	5166.0 ^c ±8.44	3309.00 ^c ±8.45	1857.00 ^c ±1.8	5150.50 ^c ± 6.1	1841.50 ^c ±2.3	4.90 ^c ±0.5	82.70 ^c ±0.4

Mean ± standard deviation for 2 determinations. Means followed by different superscript within the same column are significantly different (P≤0.05). T₀: Control, T₁: Natural fermentation, T₂: Blanching, T₃: Lacto fermentation.

Sensory Evaluation

The result for sensory evaluation is represented on Table 4. The appearance of control (T₀) and blanched plantain flour sample (T₂) has no significant difference (p≥0.05) while the natural fermented and lacto-fermented plantain flour samples have significant difference (P≤0.05). The natural fermented plantain flour sample was shown to be the least liked by the panelist. Overall acceptability shows no significant difference (p≤0.05) between the blanched and natural fermented plantain flour samples while there is significant difference (p≥0.05) between the control and the plantain flour samples. The control was ranked the highest, followed by the blanched and natural fermented plantain flour samples respectively. The lacto-fermented plantain flour sample was ranked the least by the panelist.

Table 4: Sensory evaluation of plantain flour

Samples	Texture	Appearance	Colour	Taste	Flavour	Overall acceptability
T ₀	6.50 ^a ±1.28	6.80 ^a ± 1.10	6.50 ^a ±1.30	7.55 ^a ±1.32	6.60 ^a ±0.94	7.50 ^a ± 0.76
T ₁	6.60 ^a ±1.35	6.15 ^b ± 1.14	7.20 ^c ±1.28	5.90 ^c ±1.71	6.30 ^b ±1.49	7.30 ^b ±1.30
T ₂	6.25 ^b ±1.25	7.10 ^a ± 1.51	7.45 ^b ±1.27	6.20 ^b ±1.36	5.85 ^b ±1.23	7.15 ^b ±1.23
T ₃	5.30 ^c ±1.08	6.63 ^c ± 1.25	6.25 ^a ±1.37	3.65 ^d ±1.53	4.55 ^c ±1.70	5.25 ^c ±1.37

Mean ± standard deviation. Means followed by different superscript within the same column are significantly different (P≤0.05). T₀: Control, T₁: Natural fermentation, T₂: Blanching, T₃: Lacto fermentation

4. CONCLUSION

Based on the results, it can be concluded that acceptable gruels can be made from blanched and natural fermented plantain flour samples. Results showed that the blanched and natural fermented plantain flour samples were preferred to the lacto-fermented plantain flour sample which maybe due to the fact that the lacto-fermented plantain flour is a new modification. Blanching improves least gelation and bulk density which implies that the blanched plantain flour will be a good binder and more useful as a meat extender, natural fermentation also improves the breakdown viscosity and lower breakdown viscosity indicate paste stability of the starch gel during cooking, lacto-fermentation improves gelation and water absorption capacity. Fermentation of plantain would diversify its food use when incorporated into traditional dishes for those who preferred natural enhancement of nutrients to fortification.

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