

## Full Length Research Paper

# Effects of varying temperature on physicochemical, pasting and sensory properties of plantain flour

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Accepted 02 January, 2017

The physicochemical, pasting and sensory properties of plantain flour 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 and dried in the air oven at 65°C (24 h), while the un-blanching sample served as the control. They were milled in a hammer mill, packaged in polyethylene bags and stored in a refrigerator for further analysis. Results of analysis showed that Blanching at 60, 80 and 100°C all had significant lower moisture contents ( $P < 0.05$ ) ranging from 6.41 to 6.70% compared to the un-blanching (Control 8.63%). The protein content of the blanched samples was generally lower than that of the control. The ash content of the blanched samples were significantly lower ( $P < 0.05$ ) than the un-blanching sample. As the blanching temperature increased, the fat content reduced. The crude fibre of the treated samples was not significantly different ( $P > 0.05$ ) from each other. On the basis of the pasting properties the peak viscosity was lower for the blanched samples (410.0 and 511.92 RVU) than the control sample (543.42RVU). The final viscosity was highest for the control un-blanching plantain (UBP<sub>co</sub>) flour (409.33RVU), while it ranged between 320.42 and 407.75 RVU for the blanched samples. Blanching resulted in a decrease in the bulk density of the plantain flour. Emulsion capacity decreased from 39.84% for the control sample to a range of 30.45% for sample blanched at 60°C to 17.86% for sample blanched at 100°C. Sample blanched at 60°C was scored best for taste. Samples blanched at 80 and 100°C were rated the best for colour followed by that of control and sample blanched at 60°C. The Control and the sample blanched at 60°C were rated the best in term of texture followed by that blanched at 80°C. These results showed that blanching of plantain before drying into flour had significant improvement on the physicochemical, pasting and sensory qualities of its flour.

**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. Processing of

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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 baker products have been reported by Ogazi (1986); 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 (Oduro et al., 2000). These studies were done using plantain flour from the healthy green (unripe) plantain fruits. Studies have shown that plantain, like other fruits, is susceptible to browning when pulp is sliced. The browning potential of various fruits and vegetables has been shown to be directly related to the ascorbic acid level, polyphenol 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. This study is therefore aimed at providing information on the effects of varying the blanching temperature on physicochemical, pasting and sensory 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 state, Nigeria. All reagents used were of analytical grade.

### Preparation of plantain flour

The fruits fingers were processed in the laboratory of the Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria; at green (unripe) stages. 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°C for 10 min and dried in the air oven at 65°C (24 h), while the un-blanching samples (Control) were also dried using the air oven at the same temperature of 65°C for 24 h (Baiyeri and Ortiz, 2000). The dehydrated products were milled using a disc attrition mill (Agrico Model 2A, New Delhi, India) to obtain the flour followed by sieving 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. The flours were coded as follows: PB<sub>60</sub> = Plantain blanching at 60°C, PB<sub>80</sub> = Plantain blanching at 80°C, PB<sub>100</sub> = Plantain blanching at 100°C, UBP<sub>co</sub> = Un-blanching Plantain (Control). The proximate composition was determined using AOAC (1990) procedures. The samples were also evaluated for functional properties such as water and oil absorption, emulsion capacity as described by Sathe et al. (1982), emulsion stability as described by Beuchat (1977) and the bulk density 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 according to Leach et al. (1957). The pasting properties were assessed in a Rapid Visco Analyser (RVA-4) using the RVA General Pasting Method (Newport Scientific Pty Limited, 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. A total of 20 member panelists drawn from Federal University of Technology, Akure, Nigeria in Food Science and Technology Department, assessed the sensory qualities of the reconstituted plantain flour known as "amala" in the South Western part of Nigeria. The sensory quality of "amala" made from each flour sample was measured on a standard nine-point hedonic scale. The panelists rated the amala samples for colour, taste and texture on a scale varying from 1 = dislike extremely to 9 = like extremely (Larmond, 1982). 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

### Proximate composition

The proximate composition of the blanched samples and the control are presented in Table 1. Blanching at 60, 80 and 100°C all had significant lower moisture contents ( $P < 0.05$ ) compared to the un-blanching (Control 8.63%). The lower moisture content of the blanched samples tends to suggest that blanching aids the rate of drying of the plantain chips pulverized into flour. The high value of the Control moisture content of the un-blanching Control is still within an acceptable limit for a stable shelf life as reported by Kayisu et al. (1981). The protein content of the blanched samples were generally lower than that of the control UPBCO. It reduced from 5.59% in the control sample to a range of 3.25 to 3.91% in the sample blanched samples. The higher the blanching temperature, the lower the protein content of the flour. The implication of this could be that some of the protein is either leached or denatured by the blanching process and duration. This was contrary to the observation of Fagbemi (1999) who reported that blanching had no effect on the protein content of the plantain flour. The least protein content was still within the range of values for plantain flour (2.0 to 2.7%) reported by Ikonfuo and Omurau (1988). The ash content of the blanched samples was significantly lower ( $P < 0.05$ ) than the un-blanching Control. Increase in temperature resulted in a decrease in the ash content. As the blanching temperature increases, the fat content reduced (Table 1). The lower level of fat in the blanched samples gave a higher probability of a longer shelf - life in terms of the onset of rancidity.

**Table 1.** Proximate composition of plantain (*Musa parasidiaca*) flour blanched at 60, 80 and 100°C and un-blanced control sample (UBP<sub>CO</sub>) (%db).

Parameters	UBP <sub>CO</sub>	PB <sub>60</sub>	PB <sub>80</sub>	PB <sub>100</sub>
Moisture (%)	8.63±0.05 <sup>a</sup>	6.70±0.04 <sup>b</sup>	6.54±0.06 <sup>b</sup>	6.41±0.03 <sup>b</sup>
Protein (%)	5.59±0.04 <sup>a</sup>	3.91±0.07 <sup>b</sup>	3.42±0.09 <sup>c</sup>	3.15±0.06 <sup>c</sup>
Ash (%)	2.93±0.07 <sup>a</sup>	2.58±0.03 <sup>b</sup>	2.28±0.02 <sup>c</sup>	2.19±0.10 <sup>d</sup>
Fat (%)	2.63±0.03 <sup>a</sup>	2.54±0.05 <sup>a</sup>	2.41±0.06 <sup>b</sup>	2.24±0.01 <sup>c</sup>
Total crude fibre (%)	4.27±0.06 <sup>a</sup>	2.45±0.03 <sup>b</sup>	2.27±0.03 <sup>c</sup>	2.17±0.05 <sup>c</sup>
Carbohydrate (%)	84.51±0.06 <sup>b</sup>	88.51±0.04 <sup>a</sup>	89.62±0.13 <sup>a</sup>	90.22±0.05 <sup>a</sup>
Energy (K cal)	384.33±0.15 <sup>b</sup>	392.79±0.29 <sup>a</sup>	394.09±0.27 <sup>a</sup>	393.86±0.64 <sup>a</sup>

UPB<sub>CO</sub> = Un-blanced plantain (Control), PB<sub>60</sub> = Plantain blanched at 60°C for 10 min, PB<sub>80</sub> = Plantain blanched at 80°C for 10 min and PB<sub>100</sub> = Plantain blanched at 100°C for 10 min.

**Table 2.** Functional properties of plantain (*Musa parasidiaca*) flour blanched at 60, 80 and 100°C and un-blanced control sample (UBP<sub>CO</sub>).

Parameters	UBP <sub>CO</sub>	PB <sub>60</sub>	PB <sub>80</sub>	PB <sub>100</sub>
Water absorption capacity (%)	124.50±4.50 <sup>a</sup>	118.50±0.50 <sup>b</sup>	123.50±0.50 <sup>a</sup>	125.50±0.50 <sup>a</sup>
Oil absorption capacity (%)	108.50±4.5 <sup>a</sup>	111.50±0.5 <sup>a</sup>	112.50±0.5 <sup>a</sup>	112.50±0.5 <sup>a</sup>
Bulk density (g/ml)	0.420±0.07 <sup>a</sup>	0.194±0.08 <sup>b</sup>	0.164±0.08 <sup>bc</sup>	0.159±0.07 <sup>c</sup>
Emulsion stability (%)	41.27±0.51 <sup>a</sup>	26.82±0.50 <sup>b</sup>	20.04±0.29 <sup>c</sup>	12.03±0.07 <sup>d</sup>
Emulsion capacity (%)	39.84±0.19 <sup>a</sup>	30.45±0.72 <sup>b</sup>	25.00±0.11 <sup>c</sup>	17.86±0.17 <sup>d</sup>
Swelling power (%)	48.09±0.23 <sup>a</sup>	39.98±0.12 <sup>b</sup>	38.47±2.61 <sup>c</sup>	38.19±0.33 <sup>b</sup>
Solubility (%)	5.89±0.33 <sup>a</sup>	4.77±0.04 <sup>d</sup>	4.59±0.07 <sup>b</sup>	4.14±0.07 <sup>c</sup>
Least gelation concentration (%)	2.00±0.00 <sup>c</sup>	3.00±0.00 <sup>a</sup>	4.00±0.00 <sup>b</sup>	6.00±0.00 <sup>a</sup>

UPB<sub>CO</sub> = Un-blanced Plantain (Control), PB<sub>60</sub> = Plantain blanched at 60°C for 10 min, PB<sub>80</sub> = Plantain blanched at 80°C for 10 min and PB<sub>100</sub> = Plantain blanched at 100°C for 10 min.

(Ihekoronye and Ngoddy, 1985). The crude fibre of the treated samples was not significantly different ( $P > 0.05$ ) from each other. But all treatment results were significantly lower than that of the un-blanced Control sample which was 4.27%. The caloric value of the blanched samples at the three temperatures were significantly ( $P > 0.05$ ) higher than the un-blanced Control sample but the caloric values of the treated samples were not significantly different from each other.

### Functional properties

The functional properties of the plantain flours are as shown in Table 2. The water absorption capacity of all the treated samples ranged between 118.50 to 125.50% for the blanched samples and 125.50% for the control with no significant difference among the treated samples for each temperature chosen at 10 min ( $P > 0.05$ ). Also there was no significant difference in the oil absorption capacity between the blanched and un-blanced samples. According to Fagbemi (1999) the high oil absorption capacity of the samples suggests that they may be useful in food preparations that involve oil mixing like in bakery products where oil is an important ingredient,

nonetheless, the values were still lower than the fluted pumpkin seed flour, 142% (Fagbemi and Oshodi, 1991). Blanching resulted in a decrease in the bulk density of the plantain flour, with the control maintaining highest density. This is contrary to a report made by Tagodoe and Nip (1994) which showed that bulk density increased as a result of heat treatment of flour prior to drying. The emulsion capacity and stability of the blanched samples were generally lower for the blanched samples than the un-blanced Control sample, decreasing with increasing heat. This could be as a result of heat of blanching as reported by Fagbemi (1999).

### Pasting properties

The pasting properties of the plantain flours are as shown in Table 3. 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 and highest for the control sample. 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

**Table 3.** Pasting properties of plantain (*Musa parasidiaca*) flour at 60, 80 and 100°C and un-blanch control sample (UBPco).

Parameters	UBPco	PB60	PB80	PB100
Peak Viscosity (RVU)	543.42±0.20 <sup>a</sup>	511.92±0.01 <sup>b</sup>	414.08±0.56 <sup>c</sup>	410.0±0.56 <sup>c</sup>
Trough (RVU)	325.75±0.32 <sup>a</sup>	304.67±0.01 <sup>b</sup>	276.92±4.60 <sup>c</sup>	248.92±0.04 <sup>d</sup>
Breakdown (RVU)	217.67±0.51 <sup>a</sup>	207.25±0.02 <sup>b</sup>	137.16±5.16 <sup>d</sup>	161.08±0.52 <sup>c</sup>
Final Viscosity (RVU)	409.33±0.10 <sup>a</sup>	407.75±0.03 <sup>a</sup>	366.50±0.21 <sup>b</sup>	320.42±0.10 <sup>c</sup>
Setback (RVU)	83.58±0.22 <sup>b</sup>	103.08±0.02 <sup>a</sup>	89.58±4.39 <sup>b</sup>	71.50±0.06 <sup>c</sup>
Peak time (minutes)	4.52±0.01 <sup>b</sup>	4.53±0.01 <sup>b</sup>	4.67±0.00 <sup>a</sup>	4.56±0.05 <sup>b</sup>
Pasting temperature (°C)	81.80±0.10 <sup>a</sup>	79.93±0.03 <sup>c</sup>	81.20±0.4 <sup>b</sup>	81.32±0.34 <sup>ab</sup>

UPBco = Un-blanch Plantain (Control), PB60 = Plantain blanched at 60°C for 10 min, PB80 = Plantain blanched at 80°C for 10 min and PB100 = Plantain blanched at 100°C for 10 min.

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 in this study. During the hold period, the sample was subjected to a period of constant temperature (usually 95°C) and mechanical shear stress. The period is sometimes called shear thinning, holding strength, hot paste viscosity or trough due to the accompanied breakdown in viscosity. 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 period is often associated with a breakdown in viscosity (Ragaee et al., 2006), and is an indication of breakdown or stability of the starch gel during cooking (Zaidhul et al., 2006), the lower the value the more stable the starch gel. The breakdown is regarded as a measure of the degree of disintegration of granules or paste stability (Dengate, 1984; Newport Scientific, 1995).

The breakdown viscosities recorded by blanched samples were lower than that of the un-blanch control sample. 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 occurs. It is a tendency to become firmer, with increasing resistance to enzymic attack, and also has effect on digestibility.

The final viscosity was highest for the control sample compared to 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 values of the blanched samples decreased for those blanched at 100°C, but were higher than that of the control sample from treatments blanched at 60 and 80°C (83.58 RVU). The lower setback values at higher blanching temperatures could be as a result of pre-gelatinization of the starch in the flour (Ramteke and Eipeson, 2000). The high setback value and breakdown viscosity for the samples at low blanching temperature indicates that their Paste would have a lower stability against retrogradation (Mazurs et al., 1957) than those at

high temperature. 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), and has a serious implication on the digestibility of the dough when consumed. 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 pasting temperature of the control sample was reduced by blanching, while those of the blanched samples increased with increase in temperature from 60 to 80°C. The high pasting temperature of the un-blanch control could be as a result of the presence of strong bonding forces within the granules of flour as reported by Hoover (2001). 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 pasting time was increased by blanching up treatment at 80°C and later reduced at a temperature of 100°C. This reduction must have been due to pre-gelatinization at the boiling temperature of 100°C (Adebawale et al., 2008). The peak time is a measure of the cooking time (Adebawale et al., 2005) and was higher in the two treatments blanched at higher temperatures. Generally for these samples, blanching at 60, 80 and 100°C for 10 min had a significant effect ( $P < 0.05$ ) on peak viscosity, trough, breakdown and final viscosity. Peak viscosity and trough reduced as temperature increased, while it increased for the un-blanch control sample.

### Sensory qualities

The sensory qualities of the plantain flours are shown in Table 4. The sensory qualities of "amala", the hot water reconstituted plantain flour, was rated by the panelists in terms of taste, colour and texture. Sample PB60 was scored best for taste; Sample PB80 and PB100 were rated



**Table 4.** Sensory qualities of the reconstituted plantain flour “amala”.

Sample	Taste	Colour	Texture
UPCO	5.5 <sup>b</sup>	6.9 <sup>b</sup>	7.7 <sup>a</sup>
PB <sub>60</sub>	8.7 <sup>a</sup>	6.6 <sup>b</sup>	7.5 <sup>a</sup>
PB <sub>80</sub>	3.6 <sup>d</sup>	8.0 <sup>a</sup>	5.4 <sup>b</sup>
PB <sub>100</sub>	4.6 <sup>c</sup>	7.5 <sup>a</sup>	4.6 <sup>c</sup>

Values in the same column with different superscript are significantly different at  $P < 0.05$  values are means of 20 panel scores.

the best for colour followed by UPB<sub>CO</sub> and PB<sub>60</sub>. This might have been due to inactivation of enzymes responsible for browning (Tortoe et al., 2008). Samples (UPCO) and (PB<sub>60</sub>) were rated the best in terms of texture, followed by PB<sub>80</sub>; sample PB<sub>100</sub> was scored worst. This might have been due to the pre-gelatinization of the plantain before drying, which might have made the flour lose its cohesiveness.

## Conclusion

The results from the chemical analysis has shown that blanching resulted in a decrease in protein, fat and fibre contents but increase in the carbohydrate and caloric contents. This also resulted in improvement in the bulk density, emulsion capacity and stability. There was also a decrease in the breakdown value, indicating more stability in the paste formed in the blanched samples during cooking. Blanching produced flour of high set back values at lower temperatures (60 and 80°C) but of lower value at 100°C, hence a lower tendency for retrogradation when blanched at high temperature after the final cooling of the paste. The blanched samples were rated better in terms of colour, but in terms of texture the un-blanched Control sample was best. Therefore from the results of the physicochemical, pasting and sensory evaluations obtained, blanching of plantain before drying into flour will open a vista of opportunities for the product to be applied in other formulations and utilizations.

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