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

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ABSTRACT
The effect of processing on the proximate 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 (Odoru, 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 hybrids pulp and peel mixture

<table>
<thead>
<tr>
<th>Treatment</th>
<th>MC</th>
<th>Protein</th>
<th>Starch</th>
<th>Sugar</th>
<th>Amylose</th>
<th>Fat</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW-10</td>
<td>1.99&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>73.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.55&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>19.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.66&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>HW-5</td>
<td>1.91&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>70.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.79&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>23.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CW</td>
<td>2.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>73.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.49&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>22.25&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.49&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.17&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>C</td>
<td>2.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.43&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>22.31&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.30&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
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</table>

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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>P</th>
<th>Na</th>
<th>Mn</th>
<th>Cu</th>
<th>Fe</th>
<th>Zn</th>
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<td>µg/g</td>
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<tr>
<td>HW-10</td>
<td>600&lt;sup&gt;b&lt;/sup&gt;</td>
<td>700&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11600&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>44.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>61.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>141.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>HW-5</td>
<td>700&lt;sup&gt;a&lt;/sup&gt;</td>
<td>700&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11600&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.2&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>CW</td>
<td>600&lt;sup&gt;b&lt;/sup&gt;</td>
<td>710&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11600&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1200&lt;sup&gt;a&lt;/sup&gt;</td>
<td>45.7&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>58.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>121.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>700&lt;sup&gt;a&lt;/sup&gt;</td>
<td>730&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11600&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1200&lt;sup&gt;a&lt;/sup&gt;</td>
<td>49.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>70.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>94.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.8&lt;sup&gt;a&lt;/sup&gt;</td>
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</table>

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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PV</th>
<th>TV</th>
<th>BV</th>
<th>FV</th>
<th>SV</th>
<th>PTi</th>
<th>Pte</th>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HW-10</td>
<td>179.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>158.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>232.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>HW-5</td>
<td>179.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>158.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>232.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CW</td>
<td>185.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>158.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>235.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.9&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>C</td>
<td>197.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>172.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>246.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
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</table>

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. Sufficient 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 (Dandamrongrag, *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 (Dandamrongrag, *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 movement of nutrients into the cooking medium 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).

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