Effects of ripening and pretreatment on the proximate composition and functional properties of Cardaba banana (*Musa ABB*) flour

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Abstract: Processing of Cardaba banana into flour can adequately minimize post-harvest losses and enhance utilization of this banana. This study investigated the effect of ripening and processing on the proximate composition of Cardaba banana flour. Three stages of ripening including 1 (green mature), 3 (more green than yellow) and 4 (more yellow than green) were selected for this study. The pulps were first pretreated using blanching (100^{o}C for 5 min) and sulphiting while the control was not pretreated; before being dried and milled to produce flour. The samples were evaluated for changes in proximate composition and functional properties. At the end of the research, there were significant changes in the proximate composition as a result of both ripening and pretreatment. Moisture (7.83%-9.34%), protein (2.33%-4.35%), fibre (0.27%-0.92%), increased with ripeness while ash (1.88%-2.76%), fat (2.30%-6.30%), carbohydrates (79.71%-86.69%), energy value (370.51%-388.58%), decreased with ripening. Blanching increased the moisture, ash, carbohydrate contents, of stage 1 flour; moisture, ash and energy value of stage 3 flour and the ash, protein and carbohydrate content of the stage 4 flour. Sulphiting on the other hand significantly increased the ash contents and reduced the protein and fibre contents of the flours. Bulk density (0.65-0.86 g cm^{-3}) and swelling capacity (1.13%-2.14%) increased with ripening while water absorption (106.7%-470.0%) and oil absorption capacities (43.3%-246.7%) reduced. Blanching increased most of the functional properties of the flours. The proximate and functional properties of the flours were in one way or the other affected significantly by ripening and pretreatment.

Keywords: cooking banana, processing, postharvest, ripening, flour

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1 Introduction

One way of improving the economic importance of banana is the development of whole flour which enhances rapid flour production, with improved levels of nutrients, especially minerals which are concentrated in the peel (Izonfuo and Omuoru, 1988). Whole flour could be prepared into traditional dishes and may also constitute important raw materials in food and feeding stuff formulation. Processing of fresh fruit into flour has a number of advantages, including preservation, price stability, wider availability and stimulation of agricultural production through market expansion (Ogazi, 1996). Cardaba banana (*Musa* ABB) is a cooking banana almost entirely derived from the *Musa acuminata* (AA)-AB (Diploid cultivars of Musa x paradisiaca) hybridization of AA and *Musa balbisiana* (BB) (Stover and Simmonds, 1987; Robinson, 1996). It is a disease-resistant, high yielding cooking variety that is abundant in south-eastern Nigeria and is relatively cheaper than dessert bananas and plantain, but highly restricted in utilization and highly perishable (Ayo-Omogie et al., 2010). They are very similar to unripe dessert bananas (*M. cavendishii* AAA) in exterior appearance, although often larger; the main differences being that their flesh is starchy rather than sweet (Emaga et al., 2007). The fruit usually harvested at its mature stage, ripens within two to seven days, thus making it a highly perishable crop. More recently, banana flour has been incorporated into a lot of foods due to the

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high content of resistant starch, dietary fibre and non-starch polysaccharides (Emaga et al., 2007). Some of these products include baby foods, pastries, desserts, sorbets and cream products (Ng et al., 2014). The production of flour will therefore, encourage enhanced utilization of banana. Processing of Cardaba banana into flour can adequately minimize post-harvest losses and enhance utilization of this banana. Cardaba banana is relatively cheap but highly underutilised and most of it is lost as a result of its perishability. One way of minimizing postharvest losses and increasing its utilization is by processing it into shelf stable flour. The effect of ripening on the physicochemical attributes of the flour has been studied by some researchers (Ayo-Omogie et al., 2010). Also, the suitability of incorporation of Cardaba banana flour as composite flour into numerous foods has also been studied by Ayo-Omogie and Ogunsakin (2011). However, this study investigated the effect of ripening and processing on the proximate composition and functional properties of Cardaba banana flour.

2 Materials and methods

2.1 Materials

Mature green Cardaba banana fruits (stage 1) were obtained from Ilara-mokin market in Akure, Ondo State, Nigeria and transferred to the Department of Food Science and Technology laboratory in Federal University of Technology, Akure, with utmost care avoiding any bruising. The fruits were allowed to ripen naturally at room temperature of 25°C±2°C to stage 3 (more green than yellow) and stage 4 (more yellow than green) ripeness. Ripening was monitored using the banana colour chart (United Fruits Sales, 1964). The research was conducted in May, 2016.

2.2 Design of the experiment

The experiment was a 3×3 factorial design. The factors were ripeness (green mature, more green than yellow and more yellow than green) and pre-treatments (blanched, sulphited and untreated).

2.3 Methods

2.3.1 Production of Cardaba banana flour

The method of Arisa et al. (2013) was used to produce the flours. The banana fruits bunch were cut into individual fruits and were defingered and weighed. The fruits were washed, peeled and cut to (approximately) 2 mm thick using a stainless steel knife. Blanching was carried out on some samples by placing the sliced fruits in hot water at 100°C for 5 min. They were drained and subsequently dried in a hot air oven at 60°C for 24 h. The dried Cardaba banana slices were milled using an attrition mill. This served as the blanched sample. Sodium metabisulphite ($Na_2S_2O_2$) was prepared by dissolving 1 g of the salt in a litre of water. This was made up to the quantity required. The slices were soaked in the solution for 15 min, drained and dried at 60°C for 24 h using a hot air oven. The dried slices were milled into flour. This served as the sulphited sample. The untreated Cardaba banana flour served as the control. Slices of peeled Cardaba banana were washed and placed directly into the oven and dried at 60°C for 24 h. It was milled using an attrition mill and sieved.

2.3.2 Determination of proximate composition of Cardaba banana flour

Determination of moisture content, total ash content, crude fibre, crude fat, crude protein were carried out according to the methods described by AOAC (2005), while carbohydrate was calculated by difference. Energy value was determined using the Atwater value. Results were subjected to statistical analysis using SPSS version 16.0 and Duncan multiple range test was used to separate the means.

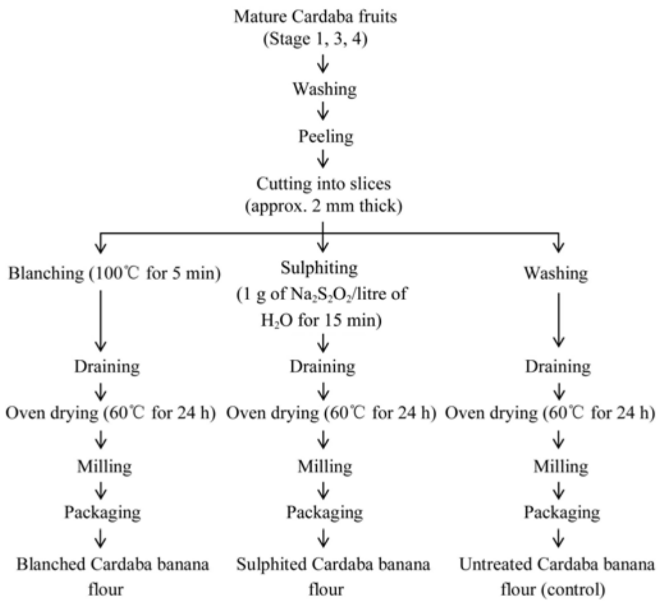

Figure 1 Flow chart for Cardaba banana flour production (Arisa et al., 2013)

2.3.3 Determination of functional properties of Cardaba banana flour

The method described by Oladele and Aina (2007) was used for the determination of bulk density. The water and oil absorption capacities of the flours were determined using the method of Sathe et al. (1982) while swelling capacity was determined using AOAC (2005).

3 Results and discussion

3.1 Effect of ripening and pre-treatment on the proximate composition of cardaba banana flour

Table 1 shows the proximate composition of Cardaba banana flour as affected by ripening and pretreatment. The moisture content ranged from 5.33%-9.34%. Moisture content was 7.83% in the green mature (stage 1), reduced to 6.95% in more green than yellow (stage 3) and increased to 8.66% in more yellow than green (stage 4). This implies that the moisture content was affected by ripening. This increase could be due to the migration of moisture from peel to pulp as ripening progressed as a result of osmosis (Marriott and Lancaster, 1983). The moisture content of flour is a very important determinant of its shelf life. The lower the moisture content, the better its storage stability (Zakpaa et al., 2010). This implies that the flour from green mature (stage 1) will store longer than that from more yellow than green (stage 4) considering the fact that high moisture content could encourage microbial growth. Ayo-Omogie et al. (2010) also reported increase in moisture content of Cardaba banana pulp during ripening from 70.45% to 74.04%. Differences in moisture contents could also be due to the differences in the processing method used in the preparation the flour. The blanching and sulphiting processes increased the moisture contents of stage 3 flour, while in stages 1 and 4, sulphiting and blanching reduced the moisture content respectively. This is in line with the findings of Ahenkora et al. (1996) who reported that blanching increased the moisture content of plantain pulp. The immersion of the pulp into water during blanching and sulphiting for 5 min and 20 min respectively could have enabled water absorption, hence the high moisture content.

The ash contents ranged from 1.88% to 2.76%. The ash content reduced from 2.34% in the green mature (stage 1) to 1.88% in the stage 3 and slightly increased to 1.95% in the more yellow than green (stage 4) flour. This implies that the ash content was significantly affected by ripening. Ayo-Omogie et al. (2010) related decrease in ash content to involvement of minerals during ripening. Blanching and sulphiting significantly increased the ash contents of the flours at all stages of ripening. The increase in the sulphited samples may be as a result of the sodium metabisulphite used in the preparation of the flour. The ash content of the stage 1, untreated flour was 2.34% which was higher than 2.00% reported by Baiyeri et al. (2011) for flour obtained from green bananas. The ash content for stage 3 untreated flour was 1.88% which is in accordance with the findings of Baiyeri et al. (2011). Untreated flour had the least ash content in all the ripening stages.

Crude protein contents were significantly low in all the samples, ranging from 2.33% to 4.35%. The protein contents were significantly affected by ripening. It reduced from 3.26% in green mature to 2.84% in stage 3 and finally increased to 3.31% in stage 4. This implies that ripening increased the protein contents of the flours. The protein contents in this study are comparable to a range of 2.48%-6.56% reported by Ayo-Omogie et al. (2010). However, the protein contents were significantly affected by pre-treatment. Blanching and sulphiting significantly decreased the protein contents of the flour samples with the exception of the stage 4 blanched flour (4.35%) which was significantly different ($P<0.05$). This implies that pre-treatment decreased the crude protein contents of the flours. The rate of decrease in the protein contents however, was higher in the blanched samples than those sulphited. This may be as a result of possible leaching of the nutrients during the process (Oluwalana and Oluwamukomi, 2011). The protein contents are also comparable to a range of 2.92%-3.07% of the findings of Baiyeri et al. (2011) for boiled plantain pulp. Fagbemi (1999) reported protein values of plantains in the range of 3.51%-3.50% in the unripe and ripe fruits respectively. This is higher than the calculated value of proteins in the green mature and more yellow than green flours in this study. Odenigbo et al. (2013) also reported protein values for cooking bananas in the range of 5.69%-6.52%.

The fat content ranged from 2.30% to 6.30%. There were inconsistencies in the fat content across the ripening stages. Fat content were significantly affected by ripening; it reduced from 6.30% in the stage 1 flour to 3.31% in stage 3 and thereafter increased to 4.28% in the stage 4 flour. Stage 1 untreated flour had the highest fat content (6.30%) which was relatively higher than 0.28% of the findings of Ayo-Omogie and Oyewole (2011) and 0.25%-0.75% by Odenigbo et al. (2013). However, the results are comparable to 1.33%- 4.65% reported by Ayo-Omogie et al. (2010). The green mature (stage 1) sulphited flour had the least fat content (2.30%). Low fat content in stored foods could indicate lower risks of spoilage as a result of rancidity. However, blanching and sulphiting significantly reduced the fat contents of the flours across the ripening stages except for more yellow than green (stage 4) which increased with sulphiting.

Crude fibre was in the range of 0.27%-0.92%. The crude fibre content was significantly affected by ripening. It increased from 0.55% in the stage 1 to 0.92% in stage 4. Similarly, pre-treatment significantly (P>0.05) affected crude fibre; blanching and sulphiting significantly reduced the crude fibre contents of the flours across all the ripening stage except for the stage 3 sulphited flour. This high crude fibre in the stage 4 untreated flour is comparable to 0.98% and 0.9% from the findings of Zapkaa et al. (2010) and Izonfou and Omuaru (1988) respectively.

Carbohydrate contents were high in all the samples ranging from 79.71% to 86.69%. Ripening had a significant effect on the carbohydrate content of the flours with an initial increase from 79.71% in green mature (stage 1) to 83.89% in more green than yellow (stage 3) and then decreased to 80.67% in more yellow than green. This may be attributed to the rapid degradation of starch and subsequent accumulation of sugars during ripening (Seymour, 1993; Turner, 2001). Cardaba banana at its green mature stage contains mainly carbohydrates especially starch (Ayo-Omogie et al., 2010). Blanching increased the carbohydrate contents of stages 3 and 4 flours and decreased that of stage 1 flour while sulphiting increased that of stage 1 and reduced stages 3 and 4. Odenigbo et al. (2013) also reported carbohydrate contents of cooking bananas between 89.37% and 92.7%. High carbohydrate contents give an insight on the energy value of a food.

The energy values of the flours are shown in Table 1. Energy value is an index for determining quality of foods especially for adult of high nutritional requirements. The energy value of the flours ranged from 370.51 to 388.58 K cal. The energy values of the flours reduced as ripening progressed from 388.58 K cal in green mature to 376.71 K cal in more green than yellow and further decreased to 374.44 K cal in more yellow than green stage. The variation in energy values could be attributed to the variation of fat, protein and carbohydrate contents (Gianni et al., 2000). More also, biosynthetic activities in the ripening fruit requires energy, hence, the decrease in energy value with ripening (Chesworth et al., 1998). Blanching and sulphiting significantly decreased the energy value of the flours except for stage 4. This decrease could be attributed to the initial leaching of nutrients during the blanching process. High energy value of the flours implies that Cardaba banana is an energy yielding food that can be consumed at any stage of ripening and can be supplemented in low energy giving foods.

Table 1 Proximate composition and energy value of Cardaba Banana flour as affected by ripening and pre-treatment

Sample	Moisture (%)	Total ash (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	CHO (%)	Energy value (K cal^{-1})
1U	7.83±.40^{c}	2.34±.05^{cd}	3.26±.05^{b}	6.30±.26^{a}	0.55±.01^{d}	79.71±.48^{f}	388.58
1B	8.60±.20^{b}	2.75±.09^{a}	2.76±.13^{c}	5.12±.72^{b}	0.52±.02^{d}	80.24±.92de	378.08
1S	5.33±.31^{e}	2.44±.04^{bc}	2.81±.10^{c}	2.30±.28^{f}	0.44±.04^{e}	86.69±.58^{a}	378.70
3U	6.95±.79^{d}	1.88±.27^{f}	2.84±.10^{c}	3.31±.05^{d}	0.66±.03^{bc}	83.89±.65^{b}	376.71
3B	7.73±.07^{c}	2.76±.11^{a}	2.33±.29^{d}	3.31±.14^{d}	0.54±.03^{d}	84.19±.42^{b}	377.91
3S	8.24±.21^{bc}	2.56±.17^{ab}	2.60±.73^{cd}	3.36±.23^{d}	0.70±.01^{b}	82.53±.28^{c}	370.76
4U	8.66±.21^{b}	1.95±.02^{ef}	3.31±.35^{b}	4.28±.57^{c}	0.92±.01^{a}	80.67±.65de	374.44
4B	8.26±.21^{bc}	2.14±.03de	4.35±.83^{a}	2.95±.79de	0.65±.01^{c}	81.64±.77^{cd}	370.51
4S	9.34±.10^{a}	2.68±.04^{b}	2.41±.22^{d}	5.45±.27^{b}	0.27±.04^{f}	79.83±.51^{f}	378.01

Note: Each value is a mean of triplicate determination. Values in the same column with same letters are not significantly different (p<0.05)1, 3, 4 (1-Stage 1 (green mature), 3-Stage 3 (more green than yellow), 4 (Stage 4 (more yellow than green); U, B, S (Untreated (Control), Blanched, Sulphited).

3.2 Effect of ripening and pre-treatment on the functional properties of Cardaba banana flour

The functional properties of the flours as affected by ripening and pre-treatment are presented in Table 2. The functional properties were inconsistent throughout the ripening stages. Bulk densities of the flours ranged from 0.65 to 0.86 g cm^{-3}. Bulk density was significantly affected by ripening, increasing from 0.67 g cm^{-3} in green mature (stage 1) to 0.86 g cm^{-3} in stage 3 and thereafter reduced to 0.82 g cm^{-3} in stage 4. The reduction in bulk density in stage 4 may be due to the high sugar content in the flour (Ayo-Omogie et al., 2010). Blanching increased the bulk density of the stage 1 flour and reduced those of stages 3 and 4. High bulk density flours could serve as good thickeners and can add to body and mouth feel of foods. Bulk density of the blanched flour from stage 1 was 0.78 g cm^{-3}. This is comparable to 0.74 g cm^{-3} reported by Ayo-Omogie and Oyewole (2011). Blanching had a positive effect on the functional properties of the stage 1 flour, it increased bulk density (0.78 g cm^{-3}), water absorption (470%), oil absorption capacities (246.7%) and the swelling power (2.14%) as compared to the untreated and sulphited samples respectively. This is in conformity with the findings of Fagbemi (1999) who reported that the functional properties of green plantain flour were enhanced by blanching. The bulk density of the stage 1 untreated sample (0.67 g cm^{-3}) was higher than 0.47 g cm^{-3} reported by Ayo-Omogie and Ogunsakin (2011). Sulphiting however, had no significant effect on the bulk densities of stages 1 and 3 flours but decreased that from stage 4.

Water absorption capacities of the flours ranged from 106.7% to 470.0%, and it decreased with ripening. Green mature (stage 1) had the highest water absorption capacity (123.3%) and more yellow than green (stage 4) had the least (106.7%). This may be attributed to the conversion of starch to sugar during ripening which are known to inhibit hydration (Fagbemi, 1999). High water absorption capacity gives an insight on the behaviour of water absorption of the flour during storage which can therefore increase or decrease the shelf life. The water absorption capacity in the stage 1 sample was 123.3% which was higher than 90.44% reported by Ayo-Omogie and Ogunsakin (2011) and in line with 125.17% of the findings of Arisa et al. (2013) for unblanched plantain flour. Sulphiting increased the water absorption capacities of the flours but the rate of increase is lower than that of the blanched samples. Good water absorbing property is essential in foods that involve reconstitution and also in the preparation of dough for pancakes and doughnuts (Gianni et al., 2000). This property may also be desirable in the baking industry where flours that produce well-mixed dough are required.

Oil absorption capacity of the flours ranged from 43.3% to 246.7%. The values were higher in stages 1 and 3 ripeness and reduced in the stage 4. Lower oil absorption capacities of the stage 4 flour is in accordance with the findings of Ayo-Omogie et al. (2010) who reported lower oil absorption values of 98.13%-67.47% for ripened Cardaba banana flour. The low oil absorption capacities of these flours may not be useful in food preparations that involve oil mixing, especially in bakery products (Ayo-Omogie et al., 2010).

Swelling capacities of the flours ranged from 1.13% to 2.14%, and it increased with ripeness from 1.13% in green mature to 1.14% in more green than yellow to 1.19% in more yellow than green (stage 4). Blanching and sulphiting increased the swelling capacity of stage 1 and 3 flour and reduced that of stage 4.

Table 2 Functional properties of Cardaba banana flour as affected by ripening and pre-treatment

Sample	Bulk density (g cm^{-3})	Water absorption capacity (g g^{-1})	Oil absorption capacity (g g^{-1})	Swelling power (%)
1U	$0.67{\pm}.01^{c}$	$223.3{\pm}23.1^{e}$	$136.7{\pm}5.8^{c}$	$1.13{\pm}.00^{e}$
1B	$0.78{\pm}.02^{b}$	$470.0{\pm}17.3^{a}$	$246.7{\pm}5.8^{a}$	$2.14{\pm}.03^{a}$
1S	$0.67{\pm}.02^{c}$	$260.0{\pm}10.0^{bc}$	$116.7{\pm}5.8^{d}$	$1.15{\pm}.01^{de}$
3U	$0.86{\pm}.03^{a}$	$146.7{\pm}5.8^{e}$	$123.3{\pm}5.8^{d}$	$1.14{\pm}.01^{de}$
3B	$0.77{\pm}.01^{b}$	$200.0{\pm}10.0^{d}$	$146.7{\pm}5.8^{b}$	$1.20{\pm}.01^{c}$
3S	$0.84{\pm}.02^{a}$	$130.0{\pm}20.0^{e}$	$96.7{\pm}5.8^{e}$	$1.14{\pm}.01^{e}$
4U	$0.82{\pm}.05^{a}$	$106.7{\pm}15.3^{d}$	$43.3{\pm}5.8^{h}$	$1.19{\pm}.01^{c}$
4B	$0.76{\pm}.01^{b}$	$243.3{\pm}5.8^{c}$	$76.7{\pm}5.8^{f}$	$1.51{\pm}.02^{b}$
4S	$0.65{\pm}.01^{c}$	$280.0{\pm}20.0^{b}$	$60.0{\pm}0.0^{g}$	$1.17{\pm}.04^{cd}$

Note: Each value is a mean of triplicate determination. Values in the same column with same letters are not significantly different ($p<0.05$). 1, 3, 4 (Stage 1 (green mature), Stage 3 (more green than yellow), Stage 4 (more yellow than green). U, B, S (Untreated (Control), Blanched and Sulphited).

4 Conclusion

Processing Cardaba banana with different pre-treatment methods had a significant effect on the quality attributes of the flour. However, these losses are within limit. The moisture and fat content which contribute greatly to the storage stability of a product are within limit. Blanching reduced the protein, fat, and the carbohydrate content of the flours while sulphiting on the other hand increased the ash content. However, some functional properties improved with blanching while others decreased.

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