Research Article

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Antioxidant Properties, Sensory Evaluation and Mineral Content of Cardaba Banana and Plantain Flours

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Abstract: Unripe cardaba banana and plantain slices were processed into flour. The effects of treatment (blanching/unblanched) and drying method (sun, 50°C and 70°C) were recorded. The antioxidant properties of the flour samples, sensory evaluation and minerals content were all determined. DPPH, TPC, FRAP and Metal chelating abilities were higher in cardaba flour (89.77 to 99.18%, 15.00 to 46.00 µgGAE/100g, 0.28 to 0.69 AAEµg/g and 38.90 to 96.53%) than in plantain (91.32 to 98.17%, 10.00 to 34.00 µgGAE/100g, 0.28 to 0.52 AAEµg/g and 33.71 to 94.98%) samples. Calcium, zinc and phosphorus were lower in cardaba banana flour compared to plantain flour. In overall acceptability, amala (a traditional South-western Nigerian meal) from blanched and unblanched cardaba banana flour was preferred to amala from blanched and unblanched plantain flour. Amala from oven-dried samples was considered better than sun-dried samples.

Keywords: Cardaba banana, Plantain, Metal Chelating, Total Phenolic Content, DPPH, FRAP, Sensory evaluation and minerals

1 Introduction

Cardaba banana is primarily a cooking banana though it can also be eaten raw. It is one of the most important banana varieties in Philippine cuisine (Porcher 1998). The fruits are 8 to 13 cm (3.1 to 5.1 in) long and 2.5 to 5.5 cm (0.98 to 2.17 in) in diameter. Depending on the ripeness, the fruits are distinctively squarish and angular. The flesh is white and starchy, making it ideal for cooking. They are

usually harvested while still green after 150 to 180 days after of flowering, especially if they are to be transported over long distances (Temanel 2007).

Cardaba is a medicinal food plant and has the potential of contributing to soil and water conservation. The fruit is tasty, sweet-sour with yellow pulp when ripe (A.F.T.D. 2012). It can be mashed and used for porridge and “*Tuozaafi*” (Bandoma 2009). Cardaba pulp is used for jam and juice production in Senegal and Burkina Faso. The latex is used to treat pulmonary diseases and tuberculosis; the leaves can cure chronic headache, wounds, food-poisoning and vomiting (Kerharo and Adam 1964).

It is also consumed as dodo (fried plantain), but not well accepted. Cardaba banana is highly perishable on ripening and deterioration is rapid within 24 hours, and thus the need for preservative methods is urgent. The banana is sliced longitudinally and sundried. Drying brings about a substantial reduction in weight and volume, thereby minimizing packaging, storage and transportation costs; this also enables storability of the product under ambient temperature, especially in developing countries (Senadeera et al. 2005). The major use traditionally is drying into flour and reconstituted as *amala* (a swallow meal of the South-western Nigeria, predominantly Yoruba Tribe).

Blanching is an important step in fruit and vegetable processing, because of the many advantages it can offer, one of which is to inactivate enzymes and also facilitate drying (Dandamrongrak et al. 2003). Minerals, including metals and non-metals, are solid inorganic elements. Many minerals are essential nutrients in that they are necessary in the diet of humans or animals to allow completion of the life cycle (I.F.I.S. 2005).

Several studies have suggested that consumption of unripe bananas exerts a beneficial effect on human health, most especially the indigestible components. Unripe bananas are a good source of carbohydrates and nutritionally interesting bioactive compounds (Ovando-Martinez et al. 2009). Antioxidants are chemicals that delay the start or slows the rate of lipid oxidation reactions.

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These compounds inhibit the formation of free radicals and hence contributes to the stabilization of the lipid sample. Natural antioxidants are constituents of many fruits and vegetables and they have attracted a great deal of public and scientific attention (El Diwani et al. 2009).

Most antioxidants are polyphenolic compounds, which act as reducing agents (free radicals terminator), metal chelators, singlet oxygen quenchers (Matthew and Abraham 2006) and hydrogen donors (Miller and Rice-Evans 1997).

Sensory quality is considered a key factor in food acceptance, because consumers seek food with specific sensory characteristics, including taste and texture for instance. The acceptance of a food will depend on whether it responds to consumer needs, and on the degree of satisfaction that it is able to provide (Heldman 2004). Antioxidant also inhibit the oxidation of other molecules, and thus can terminate these redox reactions by removing free radical intermediates, and inhibit other oxidation reactions, hence antioxidants are often reducing agents such as thiols, ascorbic acid, or polyphenols (Baillie et al. 2009).

The specific objectives are to examine the effects of processing techniques on the antioxidant properties, sensory evaluation and mineral content of the flours from cardaba banana slices in comparison to regular plantain.

2 Materials and methods

Matured unripe green banana (*Musa cardaba*) and matured unripe regular plantain fruits were obtained from the Teaching and Research Farm of OAU, Ile-Ife, Nigeria. All chemicals used were of analytical grade and were obtained from Sigma Chemicals Company, U.S.A.

S/N	Chemicals	CAS Number
1	Methanol	67-56-1
2	Vitamin C	50-81-7
3	Ferrous chloride tetrahydrate ($\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$)	13478-10-9
4	Ferrozine	63451-29-6
5	Acetate buffer (pH 3.6)	63451-29-6
6	2, 4, 6-tri-(2-pyridyl)-1, 3, 5-triazine	3682-35-7
7	Iron (III) chloride hexahydrate ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$)	10025-77-1
8	Folin-Ciocalteu's phenol reagent	5995-86-8
9	Saturated Na_2CO_3 solution	497-19-8
10	Gallic acid	205-749-9
11	Nitric acid	7697-37-2
12	HCl	7647-01-0

2.1 Preparation of Banana Flour Samples

Banana flour was produced using the modified method of Oluwalana et al. (2011) as shown in Figure 1. Cardaba banana and regular plantain were removed from their bunches manually and peeled using a sharp knife. The peeled slices were cut into 5 mm thick discs using a knife and vernier caliper. Some sliced samples were blanched by direct immersion in water at 60°C for 10 min to avoid loss of product firmness (Borges and Cal-Vidal 1994; Agunbiade et al. 2006). The samples were then withdrawn and dabbed gently with a blotting paper to remove adhering surface water and weighed using an electronic laboratory scale. The other portion was not blanched.

Figure 1: Flow Diagram for Cardaba Banana Flour Production (Modified method of Oluwalana et al. 2011)

The blanched and unblanched portions were each divided into three: the first portion was sun-dried by spreading thinly on a tray and placed under the sun to dry for 3 days (average temperature of $27 \pm 2^\circ\text{C}$); the second portion was oven dried (UNISCOPE SM9053, England) at 50°C; and the third portion was oven dried (UNISCOPE SM9053, England) at 70°C. The dried samples were milled into flour using a hammer mill. The flour was then sieved using a mesh aperture of 500 μm diameter. The sieved flour

samples were packed inside polyethylene bags, labeled and stored for analyses.

2.2 Extraction of antioxidants

Extraction of antioxidants was carried out on cardaba banana and plantain flour samples following the methods of Tabart et al. (2006) with minor modifications. About 20 g of each of the sample was mixed with 200 mL of 80% methanol. Extraction was done on a magnetic stirrer for 4 h at room temperature. After 4 h, the extract was filtered using filter paper and the solvent was distilled off under reduced pressure at 45°C using a rotary evaporator. The crude concentrated extract was used for the analyses.

2.3 DPPH (diphenyl-1-picrylhydrazyl) radical scavenging activity assay

The radical scavenging ability of the flour was determined using the stable radical DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate) as described by Pownall et al. (2010). The reaction of DPPH with an antioxidant compound, which can donate hydrogen, leads to its reduction. The change in color, from a deep violet to light yellow was measured spectrophotometrically at 517 nm. To 1 mL of different concentrations (0.2, 0.4, 0.6, 0.8 and 1.0 mg/mL) of the extract or standard (vitamin C) in a test tube was added 1 mL of 0.3 mM DPPH in methanol.

The mixture was mixed and incubated in the dark for 30 min after which the absorbance was read at 517 nm against a DPPH control containing only 1 mL methanol in place of the extract. The percent of inhibition was calculated as follows:

$$I\% = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (1)$$

Where; A_{control} = absorbance of the control reaction (containing all reagents except the test compound), and A_{sample} = absorbance of the test compound. Sample concentration was then calculated from the graph by plotting inhibition percentage against extract concentration.

2.4 Metal chelating ability assay

The metal-chelating assay was carried out according to the method by Singh and Rajini (2004) with some modifications. Solutions of 2 mM $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 5 mM ferrozine were diluted 20 times. Briefly, an aliquot (1 mL)

of different concentrations (0.2, 0.4, 0.6, 0.8 and 1.0 mg/mL) of extract was mixed with 1 mL $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$. After 5 min incubation, the reaction was initiated by the addition of ferrozine (1 mL).

The mixture was then shaken vigorously and after a further 10 min incubation period the absorbance of the solution was measured spectrophotometrically at 562 nm. The percentage inhibition of ferrozine- Fe^{+2} complex formations was calculated by using the formula:

$$\text{Chelating Effect \%} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (2)$$

where, A_{control} = absorbance of control sample (the control contains FeCl_2 and ferrozine, complex formation molecules) and;

A_{sample} = absorbance of a tested samples.

2.5 Determination of ferric reducing antioxidant power (FRAP)

The FRAP assay uses antioxidants as reductants in a redox-linked colorimetric method with absorbance measured with a spectrophotometer (Benzie and Strain 1999). The principle of this method is based on the reduction of a colourless ferric-tripyridyltriazine complex to its blue ferrous coloured form owing to the action of electron donating in the presence of antioxidants.

A 300 mmol/L acetate buffer, pH 3.6, 10 mmol/L 2, 4, 6-tri-(2-pyridyl)-1, 3, 5-triazine and 20 mmol/L $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ were mixed together in the ratio of 10:1:1, respectively, to give the working FRAP reagent. A 50 μL aliquot of the extract at 1 mg/mL and 50 μL of standard solutions of ascorbic acid (60, 80, 100 $\mu\text{g}/\text{ml}$) was added to 1ml of FRAP reagent. Absorbance measurement was taken at 593nm exactly 10 minutes after mixing against reagent blank containing 50 μL of distilled water and 1ml of FRAP reagent.

The reducing power was expressed as equivalent concentration (EC), which is defined as the concentration of antioxidant that gave a ferric reducing ability equivalent to that of the ascorbic acid standard. This was done by plotting the graph of the absorbance of ascorbic acid (standard) against concentration. The equation of the graph obtained was used to calculate the equivalent concentration based on the absorbance obtained for the extracts and this was expressed as ascorbic acid equivalent per gram of the extract (AAE/g of the extract).

Determination of Total Phenolic Content (TPC)

The total phenolic content (TPC) was determined by the method described by Singleton and Rossi (1965) as

modified by Gulcin et al. (2003) using the Folin Ciocalteu's phenol reagent which is an oxidizing reagent.

To a mixture of 0.1 mL of sample and 0.9 ml of distilled water was added 0.2 ml of Folin-Ciocalteu's phenol reagent and the resulting mixture vortexed. After 5 min of standing, 1.0 ml of 7% (w/v) saturated Na_2CO_3 solution was then added. After 2 h of incubation at room temperature, the absorbance at 750 nm was measured. A standard curve was prepared with a linear range of 0.01 – 0.1 $\mu\text{g}/\text{ml}$ using Gallic acid as the standard. The results were expressed as Gallic acid equivalent (GAE) of sample, and distilled water was used as blank.

2.6 Sensory Evaluation

The flour samples obtained from the different drying methods were made into thick “*amala*” pastes by stirring flour (50 g) inside boiling water (15 ml) (100°C) according to Abioye et al. (2011). ‘*Amala*’ reconstituted flour (in a dough form) was prepared and served without soup and was evaluated for appearance, flavor, taste, texture and overall liking of the samples by 20 semi-trained panelists. The panelists were chosen because of their familiarity with the product and were as well lectured on the grading system of the nine-point hedonic scales prior to the evaluation, where 9 = extremely like and 1 = extremely dislike. Each panelist evaluated all the samples (identified by unique three-digit codes) in a balanced sequential order. They took water in between samples. The scores obtained were subjected to analysis of variance at 5% level of significance and means separated using Duncan Multiple Range Test.

2.7 Determination of mineral Content

The analyses for mineral elements were investigated using atomic absorption spectrophotometric method (Fashakin et al. 1991). The sample (0.5 g) was weighed into digestion flask and 10 ml of nitric acid and 10 ml of HCl were added. The mixture was then digested for 10 min. The digested mixture was filtered, the filtrate made up to 50 ml with distilled water. A sample aliquot was transferred to the Auto-analyser for total phosphorus analysis at 420 nm. The left over digest was used to determine the other elements (calcium, iron and zinc) on the Atomic Absorption Spectrophotometer: 422.70, 248.30 and 213.90 nm, respectively (Perkin Elmer, model 402) while potassium was determined by methods of flame photometry.

2.8 Statistical Analysis

All determinations were made in triplicate and the data generated were subjected to one-way analysis of variance at 5% level of significance using SPSS 20.0 for Windows. Means were separated by Duncan multiple range tests.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussion

3.1 Antioxidant Activities of Cardaba Banana and Plantain Flour

Figure 2 shows the chelating abilities of cardaba banana and plantain flour samples against the standard chelating ability (E.D.T.A.). The standard chelating ability ranged from 51.02 to 75.09%, which is higher than those of cardaba banana (32.99 to 61.81%) and plantain (35.03 to 65.27%) flour samples. It was observed that the higher the concentration of the sample, the higher the chelating ability. Both cardaba banana and plantain flour samples had chelation abilities. The chelating ability in all the samples was low compared to the standard.

The chelating abilities of blanched flour samples ranged from 32.99 to 57.13% while those of unblanched flour samples ranged from 35.03 to 65.27%. Unblanched samples had higher chelating ability than the blanched samples. This could be caused by the reduction of some metals by leaching during blanching. The chelating abilities of flour from sundried samples ranged from 32.99 to 46.54%, those of flour from 50°C oven-dried samples ranged from 37.07 to 58.15% while those of flour from 70°C oven-dried samples ranged from 33.71 to 65.27%. It was observed that the higher the drying temperature the higher the chelating ability of samples (for both cardaba banana and plantain flours). Samples oven-dried at 70°C had the highest chelating ability. The chelating abilities of samples oven-dried at 50°C were higher than those of sun-dried samples. Flour samples oven-dried at 50°C had the highest chelation ability. Samples oven-dried at 50°C had the highest percentage chelation. Controlled hot-air drying of samples at low temperature (50°C) is better than at high temperature (70°C) or sun-drying.

The higher the drying temperature, the higher the chelation ability. Among the polyphenols, the presence of hydroxy (polyphenols) is related to metal ion chelating ability (Khokhar and Apenten 2003). There is a metal binding site on 3', 4'-dihydroxy position I the B-ring

Figure 2: Percentage chelation of cardaba banana and plantain flour

UHC: Unblanched Cardaba at 70 °C; **BHC:** Blanched Cardaba at 70 °C
UHP: Unblanched Plantain at 70 °C; **BHP:** Blanched Plantain at 70 °C
ULC: Unblanched Cardaba at 50 °C; **BLC:** Blanched Cardaba at 50 °C
ULP: Unblanched Plantain at 50 °C; **BLP:** Blanched Plantain at 50 °C
USC: Unblanched Cardaba sun-dried; **BSC:** Blanched Cardaba sun-dried
USP: Unblanched Plantain sun-dried; **BSP:** Blanched Plantain sun-dried

or flavonoid. Due to this position, which has electron-donating ability (Andjelkovic et al. 2006)

Percentage chelation increased gradually with concentration up to 0.8g/ml after which further increase in concentration resulted in a sharp increase in the percentage chelation.

The chelating ability of the extract measures how effective the compound in the sample can compete with ferrozine for ferrous ion. The chelating ability is regarded as an antioxidant mechanism to prevent oxidative assault on biological macromolecules such as lipids, proteins and nucleic acids. Free iron is a potential enhancer of reactive oxygen species (ROS) formation as it leads to reduction of H_2O_2 and generation of the highly aggressive hydroxyl radical (Singh and Rajini 2004). At lower drying temperature, there was no significant difference ($p < 0.05$)

in the percentage chelation of blanched samples and the unblanched samples but at higher drying temperature, the difference was significant ($p > 0.05$).

The scavenging ability of cardaba banana flour samples ranged from 89.77 to 99.18% while those of plantain flour samples ranged from 91.32 to 98.17% (Figure 3). Both cardaba banana and plantain flour samples had lower DPPH values compared to the standard (97.24 to 99.88%). The DPPH of unblanched flour samples ranged from 92.24 to 99.18% while those of blanched flour samples ranged from 89.77 to 98.17%. The effect of blanching was not significant ($p < 0.05$) on the scavenging ability of flour samples.

The DPPH of flour from sundried flour samples ranged from 91.32 to 99.18%, those of flour from 50°C oven-dried samples ranged from 92.88 to 98.17% and those

Figure 3: Percentage DPPH inhibition of cardaba banana and plantain flour

UHC: Unblanched Cardaba at 70 °C; **BHC:** Blanched Cardaba at 70 °C
UHP: Unblanched Plantain at 70 °C; **BHP:** Blanched Plantain at 70 °C
ULC: Unblanched Cardaba at 50 °C; **BLC:** Blanched Cardaba at 50 °C
ULP: Unblanched Plantain at 50 °C; **BLP:** Blanched Plantain at 50 °C
USC: Unblanched Cardaba sun-dried; **BSC:** Blanched Cardaba sun-dried
USP: Unblanched Plantain sun-dried; **BSP:** Blanched Plantain sun-dried

of flour from 70°C oven-dried samples ranged from 89.77 to 98.90%. Radical-scavenging activity using 1,1-diphenyl-2-picrylhydrazyl (DPPH) has been extensively used in the field of food processing for screening the antioxidant capacity of agricultural produce (Sanchez-Moreno 2002). DPPH radical is a stable organic free radical scavenging activity with an adsorption peak at 517 nm. Adsorption disappears when accepting an electron or a free radical species, which results in a noticeable discolouration from purple to yellow (Lin et al. 2009).

Antioxidant activity (AOA) was measured using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay (Brand-Williams et al. 1995). The increase in DPPH scavenging activity correlates directly to the extent of antioxidant efficacy of a typical plant material (Roginsky and Lissi 2005). Higher DPPH is an indication of higher free radical

scavenging ability while lower DPPH is an indication of lower free radical scavenging ability.

As presented in Figures 4, the FRAP of cardaba banana flour samples ranged from 0.28 to 0.69 AAEµg/g while those of plantain flour samples ranged from 0.28 to 0.52 AAEµg/g. Standard FRAP values ranged from 0.52 to 0.73 AAEµg/g. The FRAP of unblanched flour samples ranged from 0.30 to 0.69 AAEµg/g while those of blanched flour samples ranged from 0.28 to 0.50 AAEµg/g. Cardaba banana had higher FRAP values than plantain. Blanching the samples prior to drying reduced the FRAP of both cardaba banana and plantain flour samples.

The FRAP of flour from sundried samples ranged from 0.29 to 0.69 AAEµg/g, those of flour from 50°C oven-dried samples ranged from 0.28 to 0.68 AAEµg/g and those of flour from 70°C oven-dried samples ranged from 0.28 to

Figure 4: FRAP of cardaba banana and plantain flour

UHC: Unblanched Cardaba at 70 °C; **BHC:** Blanched Cardaba at 70 °C
UHP: Unblanched Plantain at 70 °C; **BHP:** Blanched Plantain at 70 °C
ULC: Unblanched Cardaba at 50 °C; **BLC:** Blanched Cardaba at 50 °C
ULP: Unblanched Plantain at 50 °C; **BLP:** Blanched Plantain at 50 °C
USC: Unblanched Cardaba sun-dried; **BSC:** Blanched Cardaba sun-dried
USP: Unblanched Plantain sun-dried; **BSP:** Blanched Plantain sun-dried
Stand: Standard

0.61 AAEµg/g. Drying temperature had effect on the ferric reducing activity power of the samples. Sun-dried samples had the highest FRAP values, 50°C oven-dried samples were higher in FRAP than the 70°C oven-dried samples.

Significant ($p > 0.05$) difference was observed in the FRAP of the samples. Although all the samples showed a considerable high amount of the antioxidant property, the FRAP content in all the flour samples were much lower than the standard. As reported by Juntachote and Berghofer (2005) that higher reducing power shows better abilities to donate electron and free radicals to form

stable substances, thereby interrupting the free radical chain reactions. The ferric reducing power is considered a defense mechanism which is related to the ability of the antioxidant agents to transfer electron or hydrogen atom to oxidants or free radicals (Ogunmoyole et al. 2009).

Total phenolic content (TPC) of samples is presented in Table 2. The TPC of cardaba banana flour samples ranged from 15.00 to 46.00 µgGAE/100 g while plantain flour samples had values in the range of 10.00 to 34.00 µgGAE/100g. Standard TPC ranged from 53.00 to 56.00 µgGAE/100g. The TPC of blanched flour samples ranged

Table 1: Total Phenolic Content ($\mu\text{gGAE}/100\text{g}$) of Flour

Sample	0.2 Concentration	0.4 Concentration
UHC	21.50 $\pm$ 0.01 ^{ef}	26.00 $\pm$ 0.02 ^{ef}
BHC	15.50 $\pm$ 0.01 ^h	16.00 $\pm$ 0.01 ^{hi}
UHP	25.50 $\pm$ 0.01 ^d	27.10 $\pm$ 0.03 ^{ef}
BHP	10.50 $\pm$ 0.02 ⁱ	11.00 $\pm$ 0.01 ^j
ULC	23.50 $\pm$ 0.01 ^{de}	31.00 $\pm$ 0.03 ^d
BLC	16.00 $\pm$ 0.03 ^h	19.10 $\pm$ 0.01 ^h
ULP	30.00 $\pm$ 0.01 ^c	34.20 $\pm$ 0.02 ^c
BLP	20.00 $\pm$ 0.01 ^{fg}	21.00 $\pm$ 0.01 ^g
USC	43.00 $\pm$ 0.02 ^b	46.00 $\pm$ 0.01 ^b
BSC	18.00 $\pm$ 0.02 ^{gh}	19.00 $\pm$ 0.01 ^h
USP	23.00 $\pm$ 0.01 ^{def}	31.00 $\pm$ 0.01 ^{cd}
BSP	16.00 $\pm$ 0.02 ^h	17.10 $\pm$ 0.02 ^{hi}
Stand	53.00 $\pm$ 0.01 ^a	56.00 $\pm$ 0.01 ^a

Values reported are means $\pm$ standard deviation of triplicate determinations. Mean values with different superscript within same column are significantly ($p > 0.05$) different.

UHC: Unblanched Cardaba at 70 °C; UHP: Unblanched Plantain at 70 °C
 BHC: Blanched Cardaba at 70 °C; BHP: Blanched Plantain at 70 °C
 ULC: Unblanched Cardaba at 50 °C; ULP: Unblanched Plantain at 50 °C
 BLC: Blanched Cardaba at 50 °C; BLP: Blanched Plantain at 50 °C
 USC: Unblanched Sun-dried Cardaba; USP: Unblanched Sun-dried Plantain
 BSC: Blanched Sun-dried Cardaba; BSP: Blanched Sun-dried Plantain

Table 2: Sensory Evaluation of ‘amala’ from Cardaba Banana and Plantain Flour

Sample	Appearance	Texture	Taste	Flavour	O/A
UHC	6.13 $\pm$ 1.36 ^a	6.93 $\pm$ 1.03 ^a	6.93 $\pm$ 1.10 ^a	6.60 $\pm$ 0.83 ^a	6.73 $\pm$ 1.91 ^{ab}
UHP	6.80 $\pm$ 1.57 ^a	6.00 $\pm$ 1.56 ^{abc}	6.60 $\pm$ 1.30 ^{ab}	6.67 $\pm$ 1.05 ^a	6.67 $\pm$ 1.05 ^{ab}
BHC	6.60 $\pm$ 2.00 ^a	6.53 $\pm$ 1.41 ^{ab}	6.47 $\pm$ 0.83 ^{ab}	6.40 $\pm$ 1.05 ^{ab}	7.00 $\pm$ 1.20 ^a
BHP	6.53 $\pm$ 1.84 ^a	6.07 $\pm$ 2.12 ^{abc}	6.67 $\pm$ 1.34 ^{ab}	6.47 $\pm$ 1.41 ^a	6.67 $\pm$ 1.23 ^{ab}
ULC	6.80 $\pm$ 1.37 ^a	7.07 $\pm$ 1.49 ^a	6.73 $\pm$ 1.22 ^{ab}	6.33 $\pm$ 1.72 ^{ab}	6.67 $\pm$ 1.45 ^{ab}
ULP	6.73 $\pm$ 2.28 ^a	6.60 $\pm$ 1.72 ^a	5.93 $\pm$ 1.98 ^{abc}	6.80 $\pm$ 1.08 ^a	6.60 $\pm$ 1.64 ^{ab}
BLC	6.93 $\pm$ 0.96 ^a	7.00 $\pm$ 1.41 ^a	6.53 $\pm$ 1.75 ^{ab}	6.00 $\pm$ 1.93 ^{abc}	6.93 $\pm$ 1.28 ^a
BLP	6.87 $\pm$ 1.13 ^a	7.13 $\pm$ 1.19 ^a	6.27 $\pm$ 2.10 ^{abc}	6.33 $\pm$ 1.11 ^{ab}	6.87 $\pm$ 1.30 ^a
USC	4.47 $\pm$ 2.07 ^c	4.33 $\pm$ 1.99 ^d	4.60 $\pm$ 1.36 ^d	4.93 $\pm$ 2.02 ^c	4.33 $\pm$ 1.95 ^d
USP	5.87 $\pm$ 1.06 ^{ab}	6.00 $\pm$ 1.56 ^{abc}	5.47 $\pm$ 1.76 ^{bcd}	6.00 $\pm$ 1.31 ^{abc}	5.60 $\pm$ 1.30 ^{bc}
BSC	5.80 $\pm$ 1.93 ^{ab}	4.80 $\pm$ 1.26 ^{cd}	4.60 $\pm$ 1.98 ^d	5.20 $\pm$ 1.57 ^{bc}	4.60 $\pm$ 1.40 ^{cd}
BSP	4.80 $\pm$ 1.90 ^{bc}	5.27 $\pm$ 1.87 ^{bcd}	5.07 $\pm$ 1.70 ^{cd}	5.60 $\pm$ 1.99 ^{abc}	5.20 $\pm$ 1.93 ^{cd}

Values reported are means $\pm$ standard deviation of triplicate determinations. Mean values with different superscript within same column are significantly ($p > 0.05$) different.

UHC: Unblanched Cardaba at 70 °C; UHP: Unblanched Plantain at 70 °C
 BHC: Blanched Cardaba at 70 °C; BHP: Blanched Plantain at 70 °C
 ULC: Unblanched Cardaba at 50 °C; ULP: Unblanched Plantain at 50 °C
 BLC: Blanched Cardaba at 50 °C; BLP: Blanched Plantain at 50 °C
 USC: Unblanched Sun-dried Cardaba; USP: Unblanched Sun-dried Plantain
 BSC: Blanched Sun-dried Cardaba; BSP: Blanched Sun-dried Plantain

from 10.00 to 21.00 $\mu\text{gGAE}/100\text{g}$ while those of unblanched flour samples ranged from 22.00 to 46.00 $\mu\text{gGAE}/100\text{g}$. TPC reduced with blanching and drying temperature did not have significant effect on the samples.

The TPC of flour from sundried samples ranged from 16.00 to 46.00 $\mu\text{gGAE}/100\text{g}$, those of flour from 50°C oven-dried samples ranged from 20.00 to 34.00 $\mu\text{gGAE}/100\text{g}$ and those of flour from 70°C oven-dried samples ranged from 10.00 to 27.00 $\mu\text{gGAE}/100\text{g}$. It was observed that the total phenolic content (TPC) increased as concentration increased. According to Shahidi and Naezak (2004), natural phenolic exert beneficial effects mainly through their antioxidant activities. TPC decreased with increase in drying temperature. Drying at low temperature retains the phenolic content better than drying at high temperature.

It is typically believed that the temperature–time combination applied during drying can damage nutrients and bioactive compounds, such as ascorbic acid, vitamin E, and carotenoids, phenol compounds, and flavonoids (Mrkic et al. 2006). In effect, the drying process, which includes such things as high temperature, air rich with oxygen, and microwave/ultraviolet radiation, may affect the content, activity, and bioavailability of these compounds, causing an increase or decrease of their putative health-promoting bioactivity due to physical, chemical, and biochemical changes affecting their original structures (Nguyen et al. 2013).

Also, the antioxidant effect of phenolic acids is associated with the number and position of hydroxyl groups in the molecule, hence the higher the number of hydroxyl groups on the phenyl radical of an acid, the higher the antioxidant potential (Ceriello 2008). Phenolic compounds inhibit lipid peroxidation by scavenging free radicals, such as hydroxyl radicals (OH) and peroxy radicals (ROO) resulting in the formation of low energy phenolic radicals whose energy is not sufficient to promote lipid oxidation at biologically significant rates (Decker 1988). It is known that plant phenolic compounds can be influenced by defense reactions related to pathogen attack (Nicholson and Hammerschmidt 1992).

3.2 Sensory Evaluation of Reconstituted Dough from Different Cardaba Banana and Plantain Flour Samples

The results of the sensory evaluation of dough reconstituted from cardaba banana and plantain flours are presented in Table 3. For all the unblanched samples, plantain dough (5.87 to 6.80) was preferred to cardaba dough (4.47 to 6.80) in appearance. However, for all the

blanched samples of cardaba dough (5.80 to 6.93) was preferred to plantain dough (4.80 to 6.87). Temperature of drying affected the appearance of the cardaba banana and plantain ‘*amala*’ samples, oven-dried (50°C and 70°C) ‘*amala*’ samples were not significantly ($p < 0.05$) different from each other and were highly rated (6.13 to 6.93) by panelists compared to the ‘*amala*’ samples from cardaba banana and plantain sun-dried (4.47 to 5.87). Sundried samples scored lower marks and were darker in colour. Other authors have published that dough from sundried flour products are always darker in colour compared to the oven-dried samples (Udoro et al. 2013).

Idowu et al. (2013) reported higher values (5.9 to 7.8) in appearance grading for ‘*amala*’ produced from three varieties of sweet potato while Ukpabi et al. (2008) reported lower values (2.65 to 4.20) in appearance grading for ‘*amala*’ produced from improved water yam. Production of cardaba flour into thick paste - ‘*amala*’ is unacceptable in appearance but blanching the slices prior to drying gave it a better acceptance in appearance/colour. The ‘*amala*’ from sundried flour samples were darker in colour compared to those of oven-dried samples.

The texture of ‘*amala*’ from cardaba banana flour was less preferred (4.33 to 7.07) to the texture of ‘*amala*’ from plantain flour (5.27 to 7.13). The texture of the dough from unblanched cardaba banana and plantain flours ranged from 4.33 to 7.07 while the texture of the dough from blanched cardaba banana and plantain flours ranged from 4.80 to 7.13. Dough from sundried flour samples ranged from 4.33 to 6.00, dough from 50°C oven-dried samples ranged from 6.60 to 7.13 while dough from 70°C oven-dried samples ranged from 6.00 to 6.93. ‘*amala*’ prepared from flours of oven-dried samples had better texture than ‘*amala*’ prepared from flours of sun-dried samples.

The texture of ‘*amala*’ dough from plantain flour samples were preferred to ‘*amala*’ dough from cardaba banana flour samples likewise the texture of dough from blanched flour samples were preferred to the texture of dough from unblanched flour samples. Oven-dried (50°C and 70°C) flour samples were preferred to sundried flour samples in terms of texture. All the ‘*amala*’ samples were significantly different in texture ($p > 0.05$) with values ranging from 4.33 to 7.13. Idowu et al. (2013) reported similar values (4.1 to 7.8) in texture grading for ‘*amala*’ produced from three varieties of sweet potato while Ukpabi et al. (2008) reported lower values (2.90 to 4.65) in texture grading for ‘*amala*’ produced from improved water yam.

All the flour samples except unblanched sundried cardaba (4.33) made into ‘*amala*’ dough scored above average on a 9-point hedonic scale, indicating that in terms

Table 3: Minerals content (mg/100g) of cardaba banana and plantain flours

Samples	Fe	Ca	Zn	P	K
UHC	1.22±0.02 ^e	3.30±0.03 ^{de}	0.18±0.01 ^f	9.99±0.01 ^{ef}	50.21±0.02 ^{ab}
UHP	1.18±0.03 ^f	4.34±0.04 ^a	0.25±0.01 ^{cd}	9.64±0.01 ^g	49.53±0.03 ^{ab}
BHC	1.36±0.02 ^c	2.12±0.03 ^f	0.27±0.01 ^c	11.25±0.03 ^c	47.33±0.15 ^{abc}
BHP	1.16±0.01 ^{fg}	3.33±0.03 ^e	0.31±0.01 ^{ab}	13.03±0.02 ^a	45.10±0.02 ^{bcd}
ULC	1.41±0.04 ^b	3.39±0.09 ^{de}	0.14±0.01 ^g	9.46±0.02 ^h	52.88±10.57 ^a
ULP	1.25±0.03 ^{de}	4.23±0.01 ^b	0.25±0.01 ^{cd}	10.07±0.02 ^e	40.45±0.57 ^d
BLC	1.26±0.02 ^d	1.67±0.01 ^g	0.22±0.02 ^e	9.98±0.03 ^{ef}	52.24±0.66 ^a
BLP	1.09±0.01 ^h	3.35±0.02 ^e	0.30±0.01 ^b	12.03±0.04 ^b	44.71±0.45 ^{bcd}
USC	1.61±0.02 ^a	3.47±0.01 ^d	0.25±0.01 ^{cd}	9.91±0.05 ^f	44.76±0.56 ^{bcd}
USP	1.06±0.02 ^h	4.12±0.03 ^c	0.32±0.01 ^a	9.64±0.02 ^g	42.80±0.01 ^{cd}
BSC	1.14±0.01 ^g	1.67±0.01 ^g	0.24±0.02 ^{de}	10.44±0.17 ^d	47.81±0.04 ^{abc}
BSP	1.07±0.02 ^h	2.13±0.03 ^f	0.33±0.02 ^a	10.01±0.02 ^e	46.40±0.53 ^{bc}

Values reported are means ± standard deviation of triplicate determinations. Mean values with different superscript within same column are significantly ($p > 0.05$) different.

UHC: Unblanched Cardaba at 70 °C; UHP: Unblanched Plantain at 70 °C
 BHC: Blanched Cardaba at 70 °C; BHP: Blanched Plantain at 70 °C
 ULC: Unblanched Cardaba at 50 °C; ULP: Unblanched Plantain at 50 °C
 BLC: Blanched Cardaba at 50 °C; BLP: Blanched Plantain at 50 °C
 USC: Unblanched Sun-dried Cardaba; USP: Unblanched Sun-dried Plantain
 BSC: Blanched Sun-dried Cardaba; BSP: Blanched Sun-dried Plantain

of texture only unblanched sundried cardaba was not averagely accepted. The scores for taste of reconstituted dough from cardaba banana flour ranged from 4.60 to 6.93 and was well accepted compared to that of dough from plantain flour which scores ranged from 5.47 to 6.60. Scores for dough from unblanched cardaba samples ranged from 4.60 to 6.93 in taste while blanched cardaba banana samples ranged from 4.60 to 6.53. Taste scores for dough from unblanched plantain flour samples ranged from 5.47 to 6.60 while those for blanched plantain dough ranged from 5.07 to 6.67 in taste. Dough from unblanched oven-dried cardaba at 70°C (6.93) was best preferred in taste while the dough of sun-dried cardaba sample (4.60) was least preferred. Idowu et al. (2013) reported higher values (4.7 to 8.0) in taste grading for ‘amala’ produced from three varieties of sweet potato.

The flavor of plantain dough in all the samples are more preferred to that of cardaba banana dough. From Table 3, flavor scores for cardaba banana dough ranged from 4.93 to 6.60 while that of plantain dough ranged from 5.60 to 6.80 in flavor. Flavor of dough from unblanched flour samples ranged from 4.93 to 6.80 while dough from blanched flour samples ranged from 5.20 to 6.47 in flavor.

Flavor of dough from sundried flour samples ranged from 4.93 to 6.00, 50°C oven-dried dough samples ranged from 6.00 to 6.80 for flavor while the flavor of 70°C oven-dried dough samples ranged from 6.40 to 6.67. It was observed that ‘amala’ produced from flours of oven-dried samples had better flavor than those from sun-dried flour samples.

The entire ‘amala’ samples scored above average (4.5) on a 9-point hedonic scale. This score value is lower compared to what Idowu et al. (2013) reported (5.8 to 7.5) for ‘amala’ produced from three varieties of sweet potato.

The overall acceptability of dough from cardaba banana and plantain flour samples ranged from 4.33 to 7.00 (Table 3). The overall acceptability of dough from cardaba banana flour ranged from 4.33 to 7.00 while dough from plantain flour samples ranged from 5.20 to 6.87 in overall acceptability. Dough from unblanched flour samples had overall values ranging from 4.33 to 6.73 in overall acceptability whereas dough from blanched flour samples ranged from 4.60 to 7.00 in overall acceptability.

Unblanched sun-dried cardaba had the least overall acceptance (4.33) which is lower than average on a 9-point hedonic scale. Every other sample had values above average which is an indication that they are all moderately

accepted by consumers. This is similar to what Idowu et al. (2013) reported (5.4 to 8.1) on a 9-point hedonic scale for 'amala' produced from three varieties of sweet potato. There is significant difference ($p > 0.05$) in the overall acceptability of 'amala' from cardaba and plantain flour samples.

Minerals Composition of Cardaba Banana and Plantain Flour

From Table 1, the iron content in cardaba banana flour samples (1.14 to 1.36 mg/100g) was higher than the iron content in plantain flour samples (1.06 to 1.25 mg/100g). Unblanched flour samples had iron content ranging from 1.06 to 1.61 mg/100g while blanched flour samples had iron content ranged from 1.07 to 1.36 mg/100g. This suggests that unblanched samples retained higher iron content. The iron content of flour from sundried samples ranged from 1.06 to 1.61 mg/100g, those of flour from 50°C oven-dried samples ranged from 1.09 to 1.41 mg/100g while those of flour from 70°C oven-dried samples ranged from 1.16 to 1.36 mg/100g. This suggests that the lower the drying temperature, the higher the iron content.

Coulibaly et al. (2007) reported lower values (0.3 to 0.7 mg/100g) for iron content in different varieties of plantain. Makanjuola et al. (2013) reported 0.97 to 1.21 mg/100g for different plantain cultivars. Differences in the values of iron contents reported may be due to different varieties used. Iron is an essential nutritional element, which is involved in energy metabolism, gene regulation, cell growth and differentiation, oxygen binding and transport, muscle oxygen use and storage, enzyme reactions, neurotransmitter synthesis, and protein synthesis. Iron is an important element in the diet of pregnant women, nursing mothers, infants convulsing patients and elderly to prevent anaemia and other related diseases (Oluyemi et al. 2006). *Amala* is a common staple food in South-West and will be a good source of iron to the diet.

Plantain flour samples had calcium content in the range 2.13 to 4.34 mg/100g and it is higher than that of cardaba banana flour (1.67 to 3.47 mg/100g). Blanched flour samples had calcium content ranging from 1.67 to 3.35 mg/100g while unblanched flour samples ranged from 3.30 to 4.34 mg/100g. It was observed from the results that unblanched samples are richer in calcium than blanched samples and this correlates with the findings of Arisa et al. (2013).

The calcium content of the flour from sundried cardaba and plantain samples ranged from 1.67 to 4.12 mg/100g, those of flour from 50°C oven-dried samples ranged from 1.67 to 4.23 mg/100g while those of flour from 70°C oven-dried samples ranged from 2.12 to 4.34 mg/100g. It was observed that the higher the drying temperature,

the higher the calcium content. Calcium helps in the regulation of muscle contractions transmit nerve impulses and help in bone formation (Cataldo et al. 1999). Calcium also aids in enzyme secretion, fat metabolism, egg shell formation, blood clotting, muscle growth and contraction. It also maintains a healthy heart and facilitates the passage of nutrients in and out of the cell wall (Cataldo et al. 1999). Plantain flour samples had calcium content higher than those of cardaba banana flour samples. Blanched flour samples had lower calcium content than the unblanched samples. Calcium content in flour samples increased with increase in drying temperature.

The zinc content in plantain flour samples (0.25 to 0.33 mg/100g) is more than the zinc content in cardaba banana flour samples (0.14 to 0.27 mg/100g). Unblanched flour samples had zinc content ranging from 0.14 to 0.32 mg/100g while blanched flour samples had zinc content ranging from 0.22 to 0.33 mg/100g. The zinc content of flour from sundried samples ranged from 0.24 to 0.32 mg/100g, those of flour from 50°C oven-dried samples ranged from 0.14 to 0.30 mg/100g while those of flour from 70°C oven-dried samples ranged from 0.18 to 0.31 mg/100g.

The effect of drying temperature on zinc content has no significant difference ($p > 0.05$). The values for zinc content of these samples are lower (0.14 to 0.33 mg/100g) than the zinc values that Makanjuola et al. (2013) reported for different cultivars of freshly harvested plantain (3.75 to 6.23 mg/100g). Zinc plays a vital role in gene expression, regulation of cellular growth and acts as a co-enzyme for carbohydrates, protein and nucleic acids metabolism. Some metals like copper and zinc are essential for important biochemical and physiological functions and necessary for sustaining good health throughout life (Linder and Hazegh-Azam 1996).

The result of the phosphorus content of flour samples are presented in Table 3. The phosphorus content of cardaba banana flour samples ranged from 9.46 to 11.25 mg/100g while those of plantain flour samples ranged from 9.64 to 13.03 mg/100g. The phosphorus content of blanched flour samples ranged from 9.98 to 13.03 mg/100g while those of unblanched flour samples ranged from 9.46 to 10.07 mg/100g. Blanched samples are seen to be richer in phosphorus than unblanched samples. Arisa et al. (2013) observed a similar trend for blanched and unblanched plantain.

The phosphorus content of flour from sundried samples ranged from 9.64 to 10.44 mg/100g, those of flour from 50°C oven-dried samples ranged from 9.46 to 12.03 mg/100g while those of flour from 70°C oven-dried samples ranged from 9.64 to 13.03 mg/100g. There was significant ($p > 0.05$) difference in the phosphorus concentration of

the flour samples. Consumption of cardaba banana flour may probably prevent hypophosphatemia, which is a condition of low level of phosphorus in the body (Ehrlich 2015).

Cardaba banana flour samples had potassium content ranging from 44.76 to 52.88 mg/100g while the potassium content of plantain flour samples ranged from 40.45 to 49.53 mg/100g. This suggests cardaba banana flour is slightly higher in potassium than plantain flour. The potassium content of blanched flour samples ranged from 44.71 to 52.24 mg/100g while those of unblanched flour samples ranged from 40.45 to 52.88 mg/100g. The results suggest that blanching resulted in a lower potassium content. The potassium content of flour from sundried samples ranged from 42.80 to 47.81 mg/100g, those of flour from 50°C oven-dried samples ranged from 40.45 to 52.88 mg/100g while those of flour from 70°C oven-dried samples ranged from 45.10 to 50.21 mg/100g. The higher the drying temperature, the higher the potassium content. Samples oven-dried at 70°C had the highest potassium content, samples oven-dried at 50°C had higher potassium content while samples sun-dried had the least potassium content. Consumption of cardaba banana flour may probably prevent hypertension. According to Haas (2011) supplementing potassium can be helpful in treating hypertension.

4 Conclusion

All the samples showed a considerable high amount of the antioxidant property. The higher the drying temperature, the higher the chelation ability. It was observed that the total phenolic content (TPC) increased as sample concentration increased. TPC decreased with increase in drying temperature. Drying at low temperature retains the phenolic content better than drying at high temperature.

'Amala' from Plantain flour was preferred in appearance to 'amala' from cardaba banana flour but blanching increased the preference of 'amala' from cardaba banana flour to 'amala' from plantain flour. Oven-dried samples were preferred to sun-dried samples. 'amala' from cardaba banana flour was preferred in texture and taste better than 'amala' from plantain flour. Blanching reduced the preference of texture and taste for both cardaba banana and plantain doughs. In overall acceptability, 'amala' from blanched and unblanched cardaba banana flour were preferred to 'amala' from blanched and unblanched plantain flour, oven-dried samples better than sun-dried samples.

Iron and potassium contents were higher in cardaba

banana flour than in plantain flour and they reduced with blanching. The calcium, zinc and phosphorus were lower in cardaba banana flour compared to plantain flour. Amala samples prepared from samples oven-dried at 70°C were best preferred.

Conflict of Interest: The authors hereby declare that there is no conflict of interest" on this work and that it has not been published nor under any journal consideration.

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