IJFANS

International Journal of Food And Nutritional Sciences

Volume 2, Issue 4, Oct-Dec-2013, www.ijfans.com e-ISSN: 2320-7876

Official Journal of IIFANS

IJFANS International Journal of Food And Nutritional Sciences

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
e-ISSN 2320 –7876 *www.ijfans.com*
Vol.2, Iss.4, Oct-Dec 2013

Research Paper *Open Access*

QUALITY ASSESSMENT OF FLOURS AND *AMALA* PRODUCED FROM THREE VARIETIES OF SWEET POTATO *IPOMEA BATATAS*

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ABSTRACT

Amala is a gelatinized product usually produced from cassava flour (CF) or other flours from yam tubers; and is widely consumed in the Western part of Nigeria. In this study, three varieties of sweet potato including Orange-Flesh (OF), Pink-Back-White-Flesh (PBWF) and Cream-Back-Cream-Flesh (CBCF) were processed into flours from which samples of *amala* were produced. Cassava was similarly processed to serve as control. The physical, chemical and functional properties of the flour samples were determined using standard procedures. The CF contained the highest amounts (%) of total starch (79.81) and amylose (26.41) while the lowest values of 70.99 and 21.81 were recorded for CBCF and OF, respectively. In terms of protein content, the three samples of sweet potato flour (SPF) had higher amount of protein than CF (1.31%). All the flours showed some degrees of variability in their functional properties. Flours from the three varieties of sweet potato had higher viscosities and paste clarities compared to CF. In contrast, the CF had the highest swelling capacity of 28.05 g/g when compared to the other three varieties of SPF. The mean sensory scores of *amala* obtained from PBWF and CBCF flours were significantly different ($p<0.05$) and were higher than others in terms of taste, texture and overall acceptability. In conclusion, the findings show that acceptable *amala* could be produced from the flours of different varieties of sweet potato and are comparable to the one commonly obtained from cassava flour.

Keywords: *Amala*, cassava flour, sweet potato flour, chemical composition, functional properties, sensory attributes.

INTRODUCTION

Amala is a popular starchy ethnic food that is prepared by reconstituting (cooking and stirring in boiling water) fermented yam or cassava flour (*Lafun*) produced traditionally from processed tuber flesh of certain yam or cassava (Orkwor, 1998). It is largely eaten by ethnic *Yorubas* of South-Western Nigeria. Its popularity as a *fufu*-like meal is increasing amongst non-ethnic *Yoruba* consumers in Nigeria and some other countries in the Western coast of Africa.

Lafun refers to the flour produced through the submerged fermentation of peeled cassava roots in water (Oyewole and Afolami, 2001). After fermentation, the fermented cassava is subjected to sun-drying and milled in order to obtain the *lafun* flour. To transform it into edible form, the flour is usually turned in boiling water, with no extra heating, which results in semi solid porridge. It is left to cool and can then be consumed with vegetable or any other soup of choice. Yam flour is traditionally produced by peeling raw yams and slicing into regular sizes; these are then soaked in warm water (50 - 70^{o}C) for 12 to 20 h. The sliced yams are sun dried, milled and sieved to obtain yam flour. Its transformation into *amala* is similar to that of cassava flour except that when the flour is turned in boiling water, heating is continued until effective cooking of the gelatinous mass is obtained. This could be due to the differences in chemical properties and molecular characteristics of the amylose and amylopectin contents of the two types of flour (Nuwamanya *et al.*, 2010) Yam and cassava flours are deficient in vitamins, especially vitamin A. On the other hand, sweet potato contains carotene, precursor of vitamin A; its flour could therefore be nutritionally advantageous over that of yam and cassava.

Amala is commonly consumed in the Western part of Nigeria. Since the product is exclusively obtained from yam or cassava flours, there is need to explore other sources such as sweet potato in order enhance its nutritional value especially vitamins that are grossly lacking in yam and cassava.. This will also help in enhancing availability of the product and make different varieties available to consumers. Sweet potatoes are vegetable crops which have been grossly underutilised in Nigeria, and therefore efforts at promoting their utilisation should be encouraged. With the report of an annual production of about 933,500 tonnes (FAO, 2012), Nigeria is one of the major producers of sweet potatoes in the Sub-Saharan Africa.

The sweet potato root tuber has been grossly under-utilized in Nigeria and, to the best of our knowledge, its processing into edible food product, specifically *amala*, has not been reported. The present study therefore presents findings on possible production of *amala* from the three varieties of sweet potato commonly found in Kwara State, Nigeria Results of the physical, chemical and functional properties of the different flours obtained from the sweet potatoes, in comparison to cassava flour, are also presented.

MATERIALS AND METHODS

SOURCE OF MATERIAL

The cassava and sweet potato tubers used in this study were bought from a retail market in Offa, Kwara State, Nigeria; while the orange fleshed variety of sweet potato was obtained from the experimental farm of Federal Polytechnic Offa.

FLOUR PRODUCTION FROM CASSAVA AND SWEET POTATOES

The modified methods of Ukpabi *et al*. (2008) and Oyewole and Afolami (2001) were used for production of flours from cassava (*Manihot esculenta*) and sweet potatoes (*Ipomea batatas*; Figures 1 & 2). For the flour production from sweet potatoes, the sliced tubers were conditioned in water at 50°C for 3 h before the steeping operation.

Fresh tubers
↓
1st Washing
↓
Peeling
↓
2nd Washing
↓
Slicing (~3cm thick)
↓
Conditioning (in water 50^0C for 3 h)
↓
Steeping/Fermenting (72 h, ambient temperature)
↓
Decanting
↓
Washing
↓
Drying (sun drying ~ 45°C)
↓
Milling (hammer mill)
↓
Sieving (0.5-1mm apperture)
↓
Sweet potato flour

Figure 1: Flow chart for the production of sweet potato flour (Source: Ukpabi *et al.*, 2008)

Cassava tubers
↓
Peeling
↓
Washing
↓
Steeping (3 days at ambient temperature)
↓
Dewatering (Using pressing machine)
↓
Drying (sun drying ~ 50°C)
↓
Milling (hammer mill)
↓
Sieving (0.5-1mm apperture)
↓
Cassava flour

Figure 2: Flow chart for production of cassava flour (Source: Oyewole and Afolami, 2001)

PHYSICAL AND CHEMICAL ASSESSMENT OF THE FLOURS

The parameters carried out on the different flours were moisture content, protein, ash content, pH and bulk density.

MOISTURE CONTENT

This parameter was determined according to the methods of AOAC (2000). About 2g of the sample was weighed into a dried and weighed crucible. The sample was allowed to dry at a temperature of 70^0C until constant weight was obtained. The sample was placed inside the desiccators to cool after which it was weighed.

Calculation:

$$\% \text{ moisture content} = \frac{(W_3-W_1) \times 100}{(W_2-W_1)}$$

W_1 = weight of the sample; W_2 = weight of the sample + crucible, before drying; and W_3= weight of the sample + crucible, after drying.

CRUDE PROTEIN DETERMINATION

The crude proteins in the samples were determined by the routine semi-micro Kjeldahl procedure (AOAC, 2000). Approximately 1g of the sample was placed in digestion flask. This was followed by the addition of 5g Kjedahl catalyst and 200 ml concentrated H_2SO_4 respectively. Another flask containing no sample was similarly treated to serve as a blank. The flasks were placed in inclined position and heated gently until frothing ceased; boiling continued until solution attained clarity. The flask was allowed to cool and 60 ml distilled water was cautiously added. The flask was immediately connected to digestion bulb on condenser, ensuring that the tip of the condenser was immersed in solution of standard acid and 5-7 drops of mixed indicator in the receiver. The flask was rotated to mix content thoroughly; and heated until all NH_3 is distilled. The receiver was removed and the content titrated with standard NaOH solution.

Calculation:

$$\text{Protein (\%)} = \frac{(A-B) \times N \times 1.4007 \times 6.25}{W}$$

A, volume (ml) of 0.2 N HCl used sample titration; B, volume (ml) of 0.2N HCl used in blank; N, normality of HCl; W, weight (g) of sample.

ASH CONTENT

The method of AOAC (2000) was used. Approximately 2g of the sample was weighed into a crucible and placed inside muffle furnace at temperature 550^0C until the ash is free of carbon the ash was placed in desiccators to cool after which the weight was immediately taken . The ashing process was repeated twice until a constant weight was obtained.

Calculation:

$$\text{Total ash} = \frac{(W_3-W_1) \text{ X } 100}{W_2}$$

W_1, weight of the sample; W_2, weight of the sample + crucible, before drying; W_3, weight of the sample + crucible, after drying.

pH DETERMINATION

The pH of the flour samples were determine by mixing 10g of the flour samples with 25 ml of distilled water, stirring thoroughly and measured with a pH meter (Hanna Instruments, Model 18521) at 20^oC (AOAC, 2000).

BULK DENSITY

This was done in accordance with AOAC (2000). Twenty five grams (25g) of flour was weighed into a 100 ml graduated cylinder. The cylinder was tapped ten times against palm of the hand, after which the volume of the flour was recorded. The volume was expressed as g/ml.

$$\text{Bulk density:} \frac{\text{Weight of original sample}}{\text{Volume of sample after tapping}}$$

DETERMINATION OF THE FUNCTIONAL PROPERTIES OF THE FLOURS

The functional properties of the flours determined were water absorption capacity, swelling capacity, pasting clarity, foaming capacity and pasting temperature.

WATER ABSORPTION CAPACITY

Two gram of sample was weighed and mixed with 200 ml of H_2O. The sample was stirred with a magnetic stirrer and was allowed to stand for 1h at room temperature of about 25^0C. The sample was allowed to drain dried for 35min the weight of bound water was determined by the differences (Benchat, 1977).

Calculation: WAC = total amount of H_2O added-amount decanted after centrifugation

DETERMINATION OF SWELLING CAPACITY

This was determined in accordance with the method described by Leach *et.al.* (1959) with modification for small samples. 0.1g of flour samples were weighed into weighed test tube into which 10ml of distilled water was added and heated in a water bath at temperature of 60^oC for 30 min, this was continually shaken within the heating period. At the end, the test tubes were centrifuge at 1000xg for 15min in order to facilitate the removal of the supernatant which was carefully decanted and the weight of the paste taken. The swelling capacity was calculated as follows:

$$\text{Swelling, capacity g/g} = \frac{\text{Weight of sample paste}}{\text{Weight of dry sample}}$$

DETERMINATION OF VISCOSITY

About 1g of the flour samples was weighed into a 30 ml centrifuge tube, 20 ml of distilled water was added and shake thoroughly to obtain an homogenous slurry, then 20 ml of the above slurries were pipetted into 50 ml Vitreosil viscopipette with oval bulb. The time taken in seconds by the slurry to move past the oval bulb was measured with digital stop watch capable of reading to two places of decimal.

DETERMINATION OF PASTE CLARITY

This was done using the method of Craig *et al.* (1989). About 1% (w/w) suspension of sample in distilled water was heated in a boiling water bath and stirred for 30 min. The resulting solution was cooled to room temperature, after which transmittance was measured at a wavelength of 620 nm against distilled water as blank, using UV Spectrophotometer series 2CE 202. The transmittance obtained for each sample was taken as the % paste clarity.

FOAMING CAPACITY

Foaming capacity (FC) of the flour was determined using the method of Coffman and Garcia (1977). The sweet potato flour (1g) was dispersed in distilled water (5ml) and whipped in a Kenwood blender. The whipped sample was transferred into $100cm^3$ graduate cylinder.

$$\text{Calculation:} \quad \text{FC \%} = \frac{V_2 - V_1 \text{ x } 100}{V_1}$$

V_1, volume of dispersed sample; V_2, final volume of the whipped sample

DETERMINATION OF AMYLOSE CONTENT IN FLOURS

A simplified colorimetric method described by Sowbhagya and Bhattacharya (1971) for determination of amylose content in rice was adopted. Exactly 0.1 g of flour sample was weighed into 100ml volumetric flask, and 1ml of 95% (v/v) ethanol was added to wet the sample. Then 10 ml of 0.5M KOH was added and the mixture was shaken and held overnight at room temperature. The mixture was diluted to 100 ml with distilled water and again held overnight at room temperature. 5 ml aliquot of the diluted solution was pipetted out of the mixture into another 100 ml volumetric flask and three drops of 0.1% phenolphthalein solution were added. The resulting solution was neutralized using 1M HCl, drop-wise until neutral pH was achieved. Two millilitres of 0.2% iodine solution (in 2% w/v KI) was added to the neutralized solution and made to volume with distilled water. Standard solutions of amylose of range 0 - 10 ppm were prepared from 100 ppm stock amylose solution and treated similarly like sample above. The absorbance or optical density of sample as well as standard solutions of different concentration range was taken after 30 min of addition of 0.2% Iodine solution on a spectronic 21D spectrophotometer at a wavelength of 630nm. The % amylose was calculated using the formula below:

$$\frac{\text{Absorbance of sample x gradient factor x dilution factor}}{1000}$$

DETERMINATION OF STARCH

The method of Ronald and Sawyer (1991) was used. Here, 1g of finely ground sample was defatted in a soxhlet extractor using petroleum ether at 40-60^{0}C. The defatted sample was transferred into a 250 ml beaker; 50 ml of 10% alcohol along with 50 ml of 95% alcohol were added. The mixture was properly homogenized in a homogenizer and filtered through a Whatman No 1 filter paper into another 250 ml flask and 50 ml distilled water was added to the filtrate. The mixture was placed in boiling water for 15 min with constant stirring till a homogenous mixture was obtained. The mixture was cooled to a temperature of 55^{0}C and 0.03g of diastase enzyme was added. The mixture was maintained at 55^{0}C for 1 h in the water bath. The temperature was raised to 100^{0}C and maintained for 30 min; the mixture was thereafter transferred to a 250 ml volumetric flask and made up to mark with distilled water. The mixture was filtered again into a 250 ml beaker and 20 ml of 0.1M HCl acid was added. The mixture was heated in a boiling-water bath for 2.5 h, cooled and neutralized with 0.1M Na_2CO_3 and made up to 250 ml mark with distilled water for estimation of dextrose. Standard solutions of dextrose of range 10 - 50 µg/ml were prepared from 100 µg/ml stock dextrose solution. The absorbances of standard dextrose solutions and dextrose sample extract were read on a spectronic 21D Spectrophotometer at a wavelength of 615 nm after treating with phenol-sulphuric acid reagent to give a bluish green colour upon development. The readings obtained from the standard solutions of dextrose were used to plot a standard graph, from which dextrose in the samples were extrapolated.

% dextrose is calculated using the formula:

$$\frac{\text{Absorbance of X Gradient factor x Dilution factor}}{\text{Wt. of sample x 10000}}$$

% starch = % dextrose x 0.90

DETERMINATION OF PASTING TEMPERATURE

This is the temperature at which the flour forms a gel. One gram (w/v) of flour was dissolved in 10ml of water to form slurry; this was transferred into a 30 ml test tube and then placed in a water bath at 80^{0}C for 3 h. The temperature at which a jelly paste was formed was measured by means of a thermometer.

PREPARATION OF *AMALA*

The traditional method of preparation of *amala* was adopted for the processing of the cassava and sweet potato flours into gelatinous products. This was accomplished by mixing the flours with boiling water in the ratio of 1:3 (w/v). The resulting thick paste was cooked for 5-10 min with continuous stirring, after which it was left to cool for consumption.

SENSORY EVALUATION

Sensory evaluation was carried out on the four samples of *amala* (i.e OF, PBWF, CBCF and CF) to assess for the attributes of taste, colour, flavour, texture and overall acceptability. This was determined by a ten-member panelist who are familiar with the product; using a 9-point hedonic scale of preference from 1 (dislike extremely) to 9 (like extremely). The data collected were subjected to statistical analysis, analysis of variance (ANOVA) was used to determine differences at 5% level of significance. In cases where differences occurred, the means were separated using turkey's test.

RESULTS AND DISCUSSION

PHYSICAL AND CHEMICAL PROPERTIES

Analysis of these parameters provides information about the basic constituents of the food, including moisture, ash, protein, pH, and bulk density. The results of the parameters obtained for the different flours under study are shown in Table 1. These components are fundamental to the assessment of the nutritional quality of the product being analyzed. The moisture content of food or processed product would have impact on its shelf-life and nutritive value. Low moisture content is a requirement for long storage life of foods, and low levels of the moisture in food products would enhance more concentrated forms of nutrients. The lower the moisture in food products, the more concentrated the nutrients (Zakpaa *et al.*, 2010). The PBWF had the highest moisture content (8.0%) compared to OF, CF and CBCF; the lowest value of 7.0% was recorded for CBCF. Variation in results obtained among the different flours could be due to varietal differences and probably environmental factors in areas of cultivation. The data obtained for the moisture content are supportive of those reported by Abulude and Ojediran (2004).

The results obtained for protein contents indicate that the lowest value (1.31%) was recorded for CF while sweet potato flours had higher contents. Therefore, results indicate superiority of flour obtained from sweet potatoes over cassava. Thus, sweet potato flours could be advantageous in terms of protein contents over the cassava counterpart when processed into finished products for human consumption, as this may lead to enhanced nutritional intake.

Table 1: Physical and chemical properties of the different flour samples

Sample	Moisture (%)	Protein (%)	Ash (%)	pH	Bulk density (g/ml)
OF	7.5±.02	5.5±.01	1.67±.02	5.0±.01	0.45±.02
PBWF	8.0±.01	5.1±.02	1.6±.01	5.0±.01	0.53±.01
CBCF	7.0±.02	5.7±.02	1.72±.01	5.0±.01	0.58±.01
CF	7.5±.01	1.31±.01	0.66±.01	5.6±.01	0.45±.01

Values are means of three replicates
OF, Orange-flesh sweet potato flour, PBWF, Pink-back-white-flesh sweet potato flour, CBCF, Cream-Back cream flesh sweet potato flour, CF, Cassava flour

Some varieties of orange fleshed sweet potatoes have been shown to be very rich in β-carotene, a precursor for vitamin A (Hagenimana and Jan, 2000; Ingabire and Vasanthakaalam, 2011). A similar observation, as noted for protein contents, was recorded for ash contents in the flours. The result showed that ash contents (%) of 1.67, 1.60 and 1.72 were obtained for OF, PBWF and CBCF, respectively against the lowest value of 0.66 for CF. The higher values of ash contents noted in the flours of the various sweet potatoes than in cassava, could also be nutritional advantageous to consumers. The ash in food refers to the inorganic content residue remaining after the organic matter has been burnt, and It contributes to the nutritional quality of food products (Wilson, 1987).

Bulk density is an indication of the porosity of a food product which may affect its package design and it is a function of its wet-ability; higher bulk density is a desired attribute for greater ease of dispersibility of flour. The results of the present findings indicate that sweet potato flours has higher bulk density than CF, with the exemption of OF. The bulk density was highest for the CBCF sample, having a value of 0.58g/ml while lowest value of 0.45g/ml was recorded for each of OF and CF. The value for bulk density is comparable to that obtained for sweet potato in a previous report (USDA, 1990).

Results obtained for pH shows that values obtained for the varieties of sweet potato flours were 5.0 each compared to that from cassava (5.6). The reason for this variation in the pH may be as result of higher fermentable sugars, such as sucrose, glucose and fructose, in sweet potato; this may enhance rate of fermentation in the crop (Antonio *et al*., 2011). This leads to production of more organic acids in sweet potato, thereby lowering the pH. Acid production during fermentation of most tubers, especially cassava, could generally be attributed to the activities of lactic acid bacteria along with others (Oyewole and Afolami, 2001).

FUNCTIONAL PROPERTIES OF THE FLOURS

The results of the functional properties of the flours are presented in Table 2. The water absorption capacity is a term which describes the ability of the flour to absorb or take in water during processing. The data showed that CF sample had the least value (0.82%) compared to OF (2.07%), PBWF (2.03%) and CBCF (2.04%). The higher values of water absorption capacity recorded for the flours from sweet potatoes may be due to the high polar amino acid residue of protein having affinity for molecule of water (Yusuf *et al.*, 2008). The major chemical compositions that enhance the water absorption capacity of flours are proteins and carbohydrates, since these constituents contain hydrophilic parts such as polar or charged side chain (Lawal and Adewale, 2004).

Table 2 Functional properties of the different flour samples

Samples	WAC (%)	SC (g/g)	PC (%)	Amylose content (%)	Starch content (%)	Viscosity (ml/s)	PT (^oC)
OF	2.07	16.35	57.0	21.81	71.78	1.38	78.8
PBWF	2.03	16.9	59.65	23.83	72.24	1.30	76.6
CBCF	2.04	16.0	57.5	22.26	70.99	2.65	77.7
CF	0.82	28.05	66.5	26.41	79.81	1.27	73.4

OF, Orange-flesh sweet potato flour, PBWF, Pink-back-white-flesh sweet potato flour, CBCF, Cream-Back cream flesh sweet potato flour, CF, Cassava flour, WAC, Water Absorption capacity, SC, Swelling capacity, PC, Pasting Clarity
PT, Pasting temperature

Swelling takes place when the starch is heated; the intra-molecular hydrogen bonds are broken and water is absorbed leading to swelling. Swelling capacity provides information on the nature of the associative forces within starch granules (Ogunmola *et al.*, 2001). When starch is pasted in excess water system, the granules imbibe water through the amorphous regions in a reversible manner, and the amount of water imbibed increases with temperature until a critical temperature is reached (gelatinization temperature) at which the starch swells irreversibly with loss of crystalline order. This could enhance increased volume during processing into final product for consumption. The starch granules start to swell rapidly only after the temperature reaches the onset of the gelatinization temperature.

The high swelling capacity results in high uptake of water resulting in granule expansion and leaching of amylase into solution (Pomeranz, 1990).

The result obtained showed that the swelling capacity was highest in CF (28.05%) than in sweet potato flours. Several studies have shown that swelling capacity is well correlated to amylose and its properties; flour with high amylose content tends to have high swelling capacity (Nuwamanya *et al.,* 2011).

Paste clarity are given several definitions which include the values that are given directly as the percentage transmittance read from a spectrophotometer , light reflectance characteristics and degree of whiteness of starch paste (Marrs *et al*., 1977; Nuwamanya *et al*., 2011). Pasting properties of starch are used in assessing the suitability of its application as functional ingredient in food and other industrial products. It is another important property of flour during processing as the ability of flour to form paste is useful. As noted for swelling capacity, results obtained for pasting clarity shows that the value was higher in cassava flour (66.5) compared to the sweet potato flour, OF (57.0), PBWF (59.6) and CF (57.5). The slight variation noted in result among the sweet potato flour could be due to the amylose, lipid and protein contents (Craig *et al.,* 1989). It could also be due to the botanical sources, particle size of granule, total solids concentration, degree of granule dispersion and the capacity of granules to form aggregates (Amani *et al*., 2005). The result of this finding is similar to that of Nuwamanya *et al.* (2011) who reported higher paste clarity for cassava than millet and sweet potato. The low values observed for sweet potato flour could be attributed to high amounts of carotene which may have interfered with transmission of light by the starch gel. According to Nuwamanya *et al.* (2011), cassava paste has fewer impurities on proximate analysis and therefore more light would be transmitted through it than sweet potato paste. The higher the amount of interfering substances and cases of contamination, the lower the starch clarity (Jyothi *et al*., 2007). According to Wang and White (1994), the breakdown of starch granules causes it to lose its water-holding capacity; therefore the rate of development of opacity depends on the polymer concentration and molecular weight. The rate at which samples become turbid decreases with decreasing polymer concentration and molecular weight (Miles *et al*., 1985). Lipid in food contributes to paste clarity or opacity, perhaps by restricting granular swelling (Craig *et al.*, 1989; Wang and White, 1994). Amylose content may also affect the absorbance value of these pastes.

Amylose is a soluble component of starch that is present in the flour samples (Nuwamanya *et al.,* 2011). The influence of amylose on the pasting properties of flour depends on its leaching out of the amylopectin network into the solution during heating which affects the starch present in the flour. The result obtained indicates that CF was higher in amylose content (26.4%) compared to sweet potato counterparts. The same reason asserted for paste clarity could be proffered for slight variations in values among the sweet potato flours. The amount of amylose in food substances determines stickiness of the final product when cooked (Cuevas and Fitzgerald 2007), this may be responsible for the stickiness which was discovered to be more pronounced in cassava flour.

The starch content of CF was the highest (79.81%) among the flour samples, however little variations were noted between the flour from all the varieties of sweet potato. There are two types of molecules in the starches in crops - amylose and amylopectin, and the proportions and the structures of the two molecules in starch may be the main factors that affect the cooking quality of the *amala* from tuber flours. Study by Cuevas and Fitzgerald (2007) has shown that amylose has a huge impact in the cooking quality of food products, however it cannot be used alone as predictor of quality of the food product. The amylose content and amylose characteristics of starch dictate most of its uses and in most instances determine the properties of starch. Result obtained showed that the CF has high amylose compared to sweet potato and this may be due to the variation in botanical source (Nuwamanya *et al* 2011). High amylose starches also tend to have high water absorption indices leading to firmer dough; firmness of the dough become highly pronounced as amylose content increases. The disruption of starch structure during processing and heating may result into release of amylose into solution, a process called amylose leaching. Increase in heating temperature may lead to high proportion of amylose in a solution of starch (Palav and Seetharaman, 2006; Zuluaga *et al*., 2007).

Viscosity is used to indicate the ability of starch to form various paste or gel after cooling, less stability of starch paste is commonly accompanied by high value of break down (Shimelis *et al.,* 2006; Adebayo-Oyetoro *et al*., 2012). This implies that the *amala* sample from CBCF (having the highest viscosity) may be less stable after cooling compared to those from other flours as a result of retrogradation tendency usually associated with high viscosity in food (Zaidul *et al*., 2007). The highest viscosity (2.65) was recorded for CBCF compared to other flours; 1.38, 1.30 and 1.27 were recorded for OF, PBWF and CBCF respectively. The high viscosity recorded for CBCF sample may lead to poor stability after cooling, as a result of possible retrogradation tendency (Sanni *et al.,* 2001). However, high viscosity is a desirable attribute for industrial uses in which thickening power is required such as preparations of sauces, soups, and dairy desserts (Aprianita *et al.*, 2009).

The pasting temperature recorded in this work indicated that the least PT was found in CF while higher values were recorded for the sweet potato flours. The high PT in sweet potato indicates that the starch molecules may have more mobility and hence undergo easy conformational reorganization (Petitot *et al*., 2009). On the other hand, the low value recorded in CF suggests that fewer associative forces may be present within cassava starch granules (Olayinka *et al*., 2008). It was noted that the values of the PT and SC in the present finding were inversely related to one another. A similar result was reported by Aprianita *et al.* (2009) in a research conducted on vegetable crop flours.

SENSORY EVALUATION OF AMALA

The data obtained for the sensory evaluation of *amala* prepared from the various flour samples are presented in Table 3. In the attribute of taste, the results indicate that the PBWF-A had the highest mean score of 8.0, followed closely by CBCF-A (7.8) while the lowest score (4.7) was recorded for the OF-A. The higher scores recorded for CBCF-A and PBWF-A than CF-A imply that *amala* produced from CF were less acceptable to consumers. Similar observations were noted in the attributes of colour, flavour, texture and overall acceptability. It could thus be said that *amala* samples from some of the varieties of sweet potatoes were more acceptable than that from CF, commonly eaten in the Western part of Nigeria The preference of *amala* produced from sweet potato flours over CF depicts that sweet potato *amala* could gain acceptability among customers of the product. This may help enhance the utilization of sweet potatoes, thereby reducing wastages normally associated with the crop in Nigeria.

Table 3: Mean sensory scores of *amala* obtained from the various flours.

Sample	Taste	Colour	Flavour	Texture	Overall acceptability
OF-A	4.7b	5.9b	5.8b	4.1b	5.4b
PBWF-A	8.0a	7.5a	7.5a	7.8a	8.0a
CBCF-A	7.8a	7.5a	7.3a	7.8a	8.1a
CF-A	6.4b	7.8a	7.0b	5.7b	6.6b

Mean score followed with different letters across columns are significantly different ($p < 0.05$).
OF-A, *amala* produced from Orange-flesh sweet potato flour, PBWF-A, *amala* produced from Pink-back-white-flesh sweet potato flour, CBCF-A, *amala* produced from Cream-Back cream flesh sweet potato flour, CF-A, *amala* produced from Cassava flour

CONCLUSION AND RECOMMENDATION

The ash and protein contents of the flours from sweet potatoes were higher than the cassava counterpart. The mean scores obtained for the *amala* samples from some of the sweet potato varieties in terms of the sensory attributes evaluated indicated better acceptability by panellists than that from cassava. In conclusion, acceptable and comparable *amala*,could be obtained from certain varieties of flours from sweet potato flours. Hence, processing of flours from sweet potatoes should be encouraged for the purpose of production of *amala* for consumption of people in the Western part of Nigeria. Such practices would promote the utilization of the crop and hence help in avoiding associated wastage. Consumption of *amala* from sweet potatoes could also enhance nutritional intake of consumers.

ACKNOWLEDGEMENT

The authors are grateful to **Mr O.O. Afolabi (MIPAN)** of ISV Analytical Laboratory, Ring Road, Ibadan Nigeria, where some aspects of the research work were carried out.

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