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Chemical and functional qualities of high quality cassava flour from different SMEs in Nigeria

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Abstract

In 2002, the Federal Government of Nigeria came up with the Presidential Initiative on Cassava, aimed at making cassava a cash crop, and thereafter legislated a policy the inclusion of 10% high quality cassava flour (HQCF) in wheat flour for use in Nigeria. This stimulated increased production of HQCF by small−medium enterprises ISMES across Nigeria. The flour milling industries stopped the purchase of HQCF from processors from April 2007 alleging that of HQCF of the right quality specifications was not available, among other economic reasons. This study was therefore conducted to determine the chemical composition, functional and pasting properties of HQCF obtained from different SMEs in Nigeria. Five samples of HQCF were obtained and there chemical composition, pasting and functional properties were determined using standard analytical procedures. The contents of Starch (75.5–76.6%), sugar (8.28−8.57%), and ash (0.7–0.8%) were within the Standard Organization of Nigeria (SON) standards; pH (6.5−6.9) was within the neutral range characteristic of HQCF. HCN contents (3.17−6.53 mg HCN_{eqv} / 100 g) were within the values recommended by SON (<10 mg HCN_{eqv} / 100 g). The moisture content of the HQCF samples was slightly higher than the 10% maximum recommended by SON. The chemical compositions of the HQCF samples were not significantly different, except for the protein and HCN contents. Significant variation (P<0.05) was found in the functional properties of the HQCF samples. Winnosa sample had the highest bulk density (0.66 g/cm^3), Agrivest and Jaffe had the lowest (0.58 g/cm^3). The oil absorption index ranged from 61.50% (Jaffe) to 72.50% (Fulcrum). Emulsion capacity ranged between 24.23 (Peak) and 42.74% (Jaffe). Peak flour had the highest foaming capacity (3.73%); while Jaffe had the lowest (1.48%). Dispersibility ranged from 71.50 to 80.50% and water absorption capacity ranged from 73.00 to 78.50%.The flours showed the high peak viscosities and low setback viscosities characteristic of cassava flour. The peak viscosity ranged from 132.84 to 333.46 RVU, with Agrivest flour having the lowest value and fulcrum floor the highest. Breakdown viscosity ranged from 73.84 to 173.04 RVU, Final viscosity from 88.88 to 215.75 RVU, and setback viscosities from 32.46 to 57.38 RVU. Fulcrum flour had the highest breakdown and final viscosities. Agrivest flour had the lowest breakdown viscosity; Winnosa flour had the lowest final and setback viscosities. Time to attain peak viscosity was lowest for Winnosa flour (4.30 min) and highest for Peak flour (4.60 min). The highest (79.20 °C) pasting temperature was recorded by Winnosa and the lowest (76.00 °C) by Agrivest flour. The pasting profile of the HQCF flours was significantly different (P<0.05) except for the pasting temperature. The study concluded that the quality of the HQCF samples was within the limits set by SON.

Key words*:* high quality cassava flour, chemical composition, functional properties, pasting profile, quality and standards.

Introduction

Cassava (*Manihot esculenta* Crantz) is a root crop cultivated and consumed as a staple in many regions of the developing world. Cassava, once termed the neglected crop of the down-trodden, is fast becoming an elite food crop in sub-Saharan Africa (Phillips et al 2006). Cassava has played and will continue to play a major role in efforts to alleviate the African food crisis because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions, and suitability for peasant farming and the food system in Africa (Hahn and Keyser 1985; Hahn et al 1987, Maziya-Dixon et al 2007).

The potential of the crop is large because it offers the cheapest source of food calories and the highest yield / unit area. Nigeria is the highest cassava producer in the world, producing one-third more than Brazil and almost twice the production capacity of Thailand and Indonesia (Phillips et al 2006; FAOSTAT, 2008). The country currently produces over 44 million t / year (FAOSTAT 2008); a figure expected to double by 2020. Although the world leader in cassava production, Nigeria is not an active participant in the cassava trade in the international markets because most of her cassava is targeted at the domestic food market.

In 2002, the Federal Government of Nigeria came up with the Presidential Initiative on Cassava aimed at making cassava a cash crop, This led to the legislation of a policy of 10% inclusion of high quality cassava flour (HQCF) in wheat flour for utilization by the bakery, confectionery, noodle-making and other allied companies. This stimulated increased production of HQCF by small and medium-scale enterprises (SMEs) across Nigeria. The direct consequence of the policy was that Nigerian flour-milling industries required an annual 300,000 t of HQCF. To meet this demand, various stakeholders across the federation created awareness and encouraged the establishment of cassava SMEs, which embarked on the large-scale production of HQCF in their factories.

Specifications were established by the regulatory bodies and other stakeholders. Trainings and workshops were organized by governmental and non-governmental research institutions to train potential and existing owners SMEs and workers on the techniques for producing HQCF with the right quality standards and specifications for inclusion in wheat flour for bread and confectionary. The flour-milling industries stopped the purchase of HQCF from processors from April 2007, alleging that HQCF of the right quality specifications was not available among other economic reason. This study was therefore conducted to determine the chemical composition, and functional and pasting properties of HQCF from different SMEs in Nigeria.

Materials and methods

In the study, the HQCF analyzed was obtained from different locations in Nigeria.

1) Peak Product Enterprises, km 16–17 Abeokuta − Lagos expressway, Laala village, Abeokuta, Ogun State.
2) Winnosa Global Resources Ltd, 14 Market Road, Igbogila Abavo, Delta State.
3) Fulcrum Nigeria Ltd, km 12, Iju Ebiye road, Akinleye village, Ogun state.
4) Jaffe Nigeria Ltd, km 12 Abeokuta − Lagos express way, Abule bus/stop, Obada-Oko, Ogun State.
5) Agrivest Concept International Ltd, Agbadu cassava farm, Kabba – Lokoja Expressway, Kogi State.

Determination of chemical composition. The moisture, protein, ash, crude fiber and fat contents of the samples were determined using the AOAC (1990) method. The starch and total sugar contents were determined using a colorimetric method as described by Dubois et al (1956). The amylase content was determined using the method of Williams et al (1958); cyanogenic potential was determined using the method described by Bradbury et al (1999). Phytic acid and phytate contents were determined using the method of Harland and Oberleas (1986) and the pH was determined by mixing 5 g flour in a beaker containing 25 ml of distilled water. This was allowed to stand for 30 mins with constant stirring. The pH was measured with the aid of pH meter (AOAC 1990).

Determination of functional Properties. The bulk density was determined by the method of Wang and Kinsella (1996), water absorption capacity as described by Ruales et al (1993), dispersibility by Kulkarni et al (1991), emulsion stability by Hayta et al (2002), foaming capacity and oil absorption capacity according to Sathe and Salunkhe (1981).

Determination of pasting properties. Pasting properties were determined using a Rapid Visco Analyser (RVA) (model RVA 3D+; Network Scientific, 5Australia). The sample was turned into slurry by mixing 3 g with 25 ml of water inside the RVA can. The can was inserted into the tower, which was then lowered into the system. The slurry was heated from 50 to 95 °C and cooled back to 50 °C within 12 min, The can was rotated at a speed of 160 rpm. The contents were continuously stirred with a plastic paddle. Parameters estimated were peak viscosity, trough, setback viscosity, final viscosity, pasting temperature, and time to reach peak viscosity.

Statistical Analysis. All data obtained were subjected to Statistical Analysis of Variance (ANOVA) using SPSS (version 17, 2010). Means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Chemical composition of HQCF in the Nigerian market. Table 1 shows the chemical composition of HQCF from different SMEs in Nigeria. The chemical compositions of the HQCF samples were not significantly different except for protein and HCN contents. The moisture content was slightly higher than 10% maximum recommended by Standard Organization of Nigeria (SON) (Sanni et al 2005). The lower the initial moisture content of a product to be stored, the better the storage stability of the product and the higher the efficiency of the drying method, because this shows that a considerable amount of moisture contained in the fresh sample or product has been removed. The high moisture content recorded in this study might be due to moisture absorption during storage in the factories' warehouse. The moisture content of HQCF fresh from the flash dryer (used by all the SMEs where the HQCF was sourced) usually ranged from 5 to 10% (unpublished flash dryer production efficiency audit report by Cassava: Adding Value for Africa (C:AVA Nigeria). Hence, there is the need for the SMEs producing HQCF in Nigeria to use packaging materials with very high moisture barrier properties. Also, the ambient air within their warehouses needs to be improved. This can be achieved by installing industrial air extractors to maintain the ambient relative humidity and temperature so as to minimize moisture absorption by the HQCF during storage. However, all the flour samples could still be stored for up to 7 months because their moisture contents were below the levels reported by Ukpabi and Ndimele (1990) who found that *gari* samples with a moisture content of < 16% but > 13% could be stored for 2−7 months without mold infestation. The contents of starch (75.5–76.6%), sugar (8.28−8.57%), ash (0.7–0.8%) were within the SON standards; while pH (6.5−6.9) were within the neutral range characteristic of HQCF. HQCF is simply unfermented cassava flour; hence, the almost neutral pH recorded by the samples analyzed is indicative of good GMP in the SMEs from where the flours were sourced because fermentation of cassava produces acids which tend to shift the pH of fresh cassava mash to an acidic medium. The phytic acid contents ranged from 7.45 to 8.15 mg/100 g and the phytate contents was 2.65−3.00 mg/100 g. The HCN contents of the flours (3.17−6.53 mg HCN_{eqv} / 100 g) were within the values recommended by SON (<10 mg HCN_{eqv} / 100 g) (Sanni et al 2005). The values were considerably lower than those found in *gari*, *eba*, and cooked cassava roots by Marfo et al (1990).

There is no consensus on the safe levels of cyanide for both human and animal consumption (Maziya-Dixon et al 2007) by scientists and international regulatory agencies. Mahungu et al (1987) noted that a great danger of chronic poisoning might occur if roots with more than 150 mg HCN/kg are consumed. According to Koch et al, (1992), when the peeled portion contains <50 mg HCN/kg of freshly grated cassava, the cassava can be taken as harmless to the consumer. A concentration of between 50 mg HCN/kg and 80 mg HCN/kg may be slightly poisonous; 80–100 mg HCN/kg is toxic, while concentrations above 100 mg HCN/kg of grated cassava are fatal (Koch et al 1992; Maziya-Dixon et al 2007). Presently in Nigeria, grating/crushing is being promoted in production of high quality cassava flour (HQCF) because it leads to the production of flour with negligible amounts of residual cyanide contents after drying. The joint FAO/WHO Food Standards Program Codex Committee on Contaminants in Foods (JECFA) 3rd Session held in the Netherlands in 2009 concluded that a level of up to 10 mg HCN/kg in the Standard for Edible Cassava Flour (CODEX STAN 176-1989) was not associated with acute toxicity (WHO 1993). A review of the available data by European Food Safety Authority (EFSA Journal) in 2004 arrived at a similar conclusion (JECFA 2009).

Functional properties of HQCF in Nigerian markets. The results of rests of the functional properties of HQCF from different SMEs in Nigeria are presented in (Table 2). Significant variation ($P<0.05$) was found in the functional properties of the Table 2 samples. Winnosa sample had the highest bulk density (0.66 g/cm^3); Agrivest and Jaffe had the lowest (0.58 g/cm^3). The bulk density is an important parameter that determines the ease of packaging and transportation of particulate foods. The bulk density of the flours is comparable to values reported by Shittu et al (2007) for HQCF from 43 cassava varieties resistant to mosaic disease (CMD). The oil absorption index ranged from 61.50% (Jaffe) to 72.50% (Fulcrum). Oil absorption is an indication of the amount of oil that can be absorbed by the physical matrix of a food. It indicates the degree of hydrophobicity (Voutsinus and Nakai. 1983) of flour. Emulsion capacity ranged between 24.23 (Peak) and 42.74% (Jaffe). Peak flour had the highest foaming capacity (3.73%) while Jaffe had the lowest (1.48%). Dispersibility ranged from 71.50 to 80.50% and water absorption capacity from 73.00 to 78.50%. Dispersibility is a measure of the degree to which of flour or flour blends reconstitute in water; the higher the dispersibility, the better the flour reconstitutes in water (Adebowale et al 2005). The higher dispersibility values exhibited by all the Samples of HQCF analyzed are indicative of their ability to produce a smooth dough in composite with wheat flour.

Pasting properties of HQCF in Nigerian markets. The pasting profile of high quality cassava flour samples from different SMEs in Nigeria is shown in Table 3. The peak viscosity ranged from 132.84 to 333.46 RVU with Agrivest flour having the lowest and Fulcrum hlour the highest. Breakdown viscosity 73.84 to 173.04 RVU, Final viscosity from 88.88 to 215.75 RVU, and setback viscosities ranged, and from 32.46 to 57.38 RVU. The time to attain peak viscosity was lowest for Winnosa flour (4.30 min) and highest for Peak flour (4.60 min). The highest (79.20 °C) pasting temperature was recorded by Winnosa flour and the lowest (76.00 °C) was recorded Agrivest flour. The pasting profiles of the HQCF flours were significantly different (P<0.05) except for the pasting temperature. One of most common methods for determining the pasting profile of starch-based food products is through an amylograph pasting profile. Information on the pasting profile of flours has been used to correlate the functionality of starchy food ingredients in processes such as baking (Idowu et al 1996; Rojas et al 1999) and extrusion cooking (*Ruales* et al 1993). The peak viscosity is the maximum viscosity attainable during the heating cycle; the trough is an index of the starch granules' stability in heating; setback viscosity is an index of the retrogradation of linear starch molecules during cooling. It has been very difficult from past work to predict the bread-making potentials of cassava flour without wheat floor from its amylograph pasting properties. However, in agreement with previous work, it was concluded that attaining gelatinization at a lower temperature led to improved bread-baking quality (Defloor et al 1994). High peak viscosity and stability (or low breakdown viscosity) were also associated with cassava starch which produces acceptable bread (Adeyemi et al 1978). The flours showed the high peak viscosities and low set back viscosities characteristic of cassava

Table 1: Chemical composition of HQCF in Nigerian markets.

Composition (%)	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Moisture^{ns} (%)	14.47	14.56	14.56	14.36	14.41
Protein (%)	0.96 a	1.49 c	1.31 bc	1.14 ab	0.96 a
Fat^{ns} (%)	0.50	0.40	0.50	0.50	0.50
Amylose^{ns} (%)	13.40	13.30	13.20	13.50	13.00
Sugar^{ns} (%)	8.35	8.52	8.57	8.44	8.28
Starch^{ns} (%)	75.6	76.6	75.5	75.9	75.7
Ashns (%)	0.80	0.80	0.70	0.80	0.70
Crude Fiber^{ns}	1.50	1.54	1.60	1.54	1.48
Phytic acid^{ns} (mg/100g)	8.00	8.35	7.45	7.45	8.15
Phytate^{ns} (mg/100g)	2.85	3.00	2.65	2.65	2.90
HCN (mg HCN_{eqv}/100g)	5.15c	6.53cd	3.17a	4.36b	5.94c
pH^{ns}	6.70	6.70	6.90	6.50	6.50

- Values are means of 2 replicates
- Mean values having different superscript within row are significantly different (P <0.05).
- ns not significantly different

Table 2: Functional properties of HQCF in Nigerian markets.

Properties	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Bulk Density (g/cm3)	0.60ab	0.66c	0.58a	0.58a	0.63bc
Oil Absorption Capacity (%)	70.50c	66.25b	66.00b	61.50a	72.50c
Dispersibility (%)	78.00b	80.50c	79.00bc	71.50 a	79.00bc
Foaming capacity (%)	3.73c	2.66abc	2.06ab	1.48a	2.77bc
Emulsion Capacity (%)	42.74d	34.59c	27.27ab	24.23a	32.69bc
Water Absorption Capacity (%)	74.00b	78.50d	74.50bc	76.00c	73.00a

- Values are means of 2 replicates
- Mean values having different superscript within the same row are significantly different (P<0.05).
- ns not significantly different

Table 3: Pasting properties of HQCF in Nigerian markets.

Variables	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Peak (RVU)	279.30^{b}	132.84^{a}	158.46^{a}	277.58^{b}	333.46^{c}
Trough (RVU)	134.27^{cd}	56.42^{a}	84.63^{b}	123.75^{c}	160.42^{d}
Break down viscosity (RVU)	145.09^{b}	76.42^{a}	73.84^{a}	154.34^{b}	173.04^{c}
Final viscosity (RVU)	185.54^{b}	88.88^{a}	122.75^{a}	181.13^{b}	215.75^{b}
Setback (RVU)	51.34^{a}	32.46^{b}	38.13^{b}	57.38^{a}	55.34^{a}
Pasting time (min)	4.60^{bc}	4.30^{a}	4.40^{ab}	4.50^{bc}	4.37^{ab}
Pasting temperature (°C)^{ns}	78.9	79.2	76.0	78.8	78.4

- Values are means of 2 replicates
- Mean values having different superscript within row are significantly different ($P < 0.05$).
- ns not significantly different ($P>0.05$).

flour. Further works is needed to really determine quantitatively how the pasting properties of cassava flour relate to its functionality or end use, especially in baking, bread pastry, and confectionary.

Conclusion

The quality characteristics of the five samples of HQCF investigated for their quality characteristics showed significant variations ($P<0.05$) in some of quality parameters evaluated. The functional properties of the flour samples were significantly different ($P<0.05$). Significant differences ($P<0.05$) were recorded in the pasting profile of the flour samples, except for the pasting temperature. The qualities of the HQCF samples were within the limits set by the SON and the Codex.

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