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Evaluation of proximate composition and pasting properties of high quality cassava flour (HQCF) from cassava genotypes (*Manihot esculenta Crantz*) of β-carotene-enriched roots

Emmanuel Oladeji Alamu [a], Bussie Maziya-Dixon [a, *], Alfred Gilbert Dixon [b]

[a] *Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), PMB 5320, Oyo Road, Ibadan, Oyo State, Nigeria*
[b] *Weed Science Management Project, International Institute of Tropical Agriculture (IITA), PMB 5320, Oyo Road, Ibadan, Oyo State, Nigeria*

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ABSTRACT

Cassava farmers are yet to fully exploit its full potential in terms of improvement of livelihood. Forty-five genotypes of cassava genotypes were processed into High Quality Cassava Flour (HQCF). These genotypes were planted in two sets, set 1 comprised 22 clones of β-carotene enriched roots and 3 check clones of white roots and set 2 comprised 18 clones and 2 check clones. The effects of variety on the proximate composition and pasting profile of the flour were investigated. The starch content ranged between 67.1 g/100 g (for 01/1663) and 82.4 g/100 g (for 30572) in set 1 and between 69.6 (01/1560) to 77.8 g/100 g (for Z97/0474) in set 2. Peak viscosity values ranged between 295.6 RVU (rapid visco unit) (30572) and 467.0 RVU (01/1115) across clones in set 1 while for set 2, it ranged from 271.9 RVU (for 01/1404) to 471.3 RVU (for 01/1417). Significant differences ($P < 0.05$) existed in the proximate composition and pasting properties of the flour from different cassava genotypes investigated. The high peak viscosity exhibited by most genotypes is indicative that the flour may be suitable for products requiring high gel strength and elasticity. The proximate composition compares competitively with values obtainable from conventional clones.

1. Introduction

Cassava (*Manihot esculenta* Crantz) is a root crop cultivated and consumed as a staple in many regions of the developing world. Africa produced 157.7 MT of cassava in 2012 and Nigeria produced 53.0 MT, making it the most important root crop (FAOSTAT, 2015) and a major source of dietary calories. The importance of cassava to the livelihoods of many millions of poor people has made the commodity a target for interventions. Cassava is known to be grown in areas where mineral and vitamin deficiencies are widespread, especially in Africa. A marginal nutrient status increases the risk of morbidity and mortality. Therefore, improving the nutritional value of cassava could alleviate some aspects of hidden hunger, that is, subclinical nutrient deficiencies without overt clinical signs of malnutrition (Montagnac, Davis, & Tanumihardjo, 2009). This also depends on how traditional processing and food preparations will impact the nutritional value and physicochemical properties of cassava roots.

About 65% of cassava productions are for human consumptions, 25% is for industrial use and 10% is lost as waste (Fish & Trim, 1993). In Nigeria, more than 40% of cassava is currently processed, mainly into traditional food products. There are many opportunities to extend the traditional uses of cassava, especially processing into high quality cassava flour (HQCF). This product could be introduced it into a wide range of new food products, particularly in the rapidly urbanizing societies of the developing countries. Cassava is well known to be perishable and bulky and to overcome these limitations, it requires appropriate strategies and technology for post-harvest processing and utilization. Processing of fresh cassava roots provide a means of producing shelf-stable products (thereby reducing losses), adding value at a rural level, and reducing the bulk to be marketed (Dufour, O'Brien, & Best, 2002, p. 409). HQCF is popular in the food industry because of its special characteristics - clarity of appearance, low flavor overtones, and ideal viscosity. It has been tested as filler in comminuted meat products (Annor-Frempong, Annan-Prah, & Wiredu, 1996). Some newly tested applications of HQCF in recent years have been as weaning foods, as

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* Corresponding author. International Institute of Tropical Agriculture (IITA), Carolyn House 26 Dingwall Road, Croydon CR9 3EE, England, United Kingdom.
E-mail address: b.dixon@cgiar.org (B. Maziya-Dixon).

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substrates in alcohol production, and for glucose syrup production (Adewusi, Orisadare, & Oke, 1992; Pontoh & Low, 1995). However, processing cassava root into food forms and raw materials such as flour, chips and pellets can extend the shelf life, facilitate trade and promote industrial use. Some authors have studied the chemical, functional and pasting properties of cassava starch and soy protein concentrate blends (Chinma, Ariahu, & Abu, 2013), tapioca grits from different cassava varieties and roasting methods (Adebowale, Sanni, & Onitilo, 2008) and cassava starch and mushroom flour blends intended for biofilm processing (Ojo, Ariahu, & Chinma, 2017). Chinma et al. (2013) reported that addition of varying levels of soy protein concentrates to cassava starch led to increase in protein (from 0.32 to 79.03 g/100 g), ash (from 0.45 to 2.67 g/100 g) and fat (from 0.17 to 0.98 g/100 g) contents while crude fiber, carbohydrate and amylose contents decreased from (1.19–0.38 g/100 g, 90.77 to 57.01 g/100 g and 29.45 to 23.04 g/100 g) respectively. Adebowale et al. (20008) reported amylose content of the tapioca grits to range between 22.95 g/100 g and 24.30 g/100 g, and the protein and fat content of the tapioca grits ranged from 0.23 to 0.26 g/100 g and from 0.12 to 0.25 g/100 g respectively. However, Ojo et al. (2017) recorded the proximate composition for the starch-mushroom blend to range from 8.79 to 9.35 g/100 g, 0.55–26.23 g/100 g, 0.34–2.01 g/100 g, 0.32–8.24 g/100 g and 0.10–17.86 g/100 g for moisture, protein, fat and ash respectively while Carbohydrate ranged from 36.31 to 89.62 g/100 g and amylose contents 18.47–25.35 g/100 g. All these studies used white cassava varieties and none has reported to use yellow root cassava varieties. However, there is scanty information on the proximate composition and pasting properties of HQCF from cassava genotypes (Manihot esculenta Crantz) of β-carotene-enriched roots.

Processing cassava can affect the nutritional value of cassava roots through modification and losses in nutrients of high value and cause changes to the physicochemical properties. This study attempts to evaluate the proximate composition and pasting properties of HQCF from cassava genotypes of β-carotene-enriched roots with a view to providing information that will guide breeding programmes and end use.

2. Materials and methods

2.1. Cassava roots

A total of 45 yellow cassava genotypes were grown in 2003/04 cropping season in replicated field trials (Randomized Complete Block Design) at the research farm of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The 45 genotypes were planted in 2 sets. Set 1 comprised 22 clones with β-carotene enriched roots and three check clones with white roots (30572, TME 1, and 91/02324), set 2 comprise 18 clones with β-carotene enriched roots and two check genotypes with white roots (30572 and 91/02324). Cassava breeders have tried to improve the nutritional value and physicochemical properties of cassava by cross-breeding wild-type varieties. The two sets were different from each other by the source (parent lines with different quality traits) used for their breeding crosses, which could possibly dictate the chemical properties of the processed products from the genotypes. Both sets of genotypes were planted during the raining season in July and grown under rain fed conditions in a replicated complete block design with four replicates. No fertilizers or herbicides were applied during the experiment. Hand weeding was done when necessary. Harvesting was done at 12 months after planting (MAP). Only the two middle rows were harvested per plot and all processed cassava roots were collected from 2 replicates of the 4 replicates in the design. The processing of the roots was started within 60 min but completed within 24 h of harvesting.

2.2. Methods

2.2.1. Preparation of high quality cassava flour (HQCF)

Ten (10) kg of freshly harvested cassava roots were peeled, washed, grated, dewatered, and sieved. The resulting sieved mash was oven-dried at 40 °C and milled (sieve size, 0.5 mm). The processing and chemical analyses were done in 2 replications.

2.2.2. Determination of proximate composition

2.2.2.1. Moisture content determination. This was determined using AOAC method (1990). The sample was dried at 100–105 °C for 24 h in a draft air Fisher Scientific IsotempR Oven model 655 F (Loughborough, United Kingdom). The loss in weight was recorded as moisture.

2.2.2.2. Ash content determination. This was determined by the method of AOAC (1990). The method involved burning off moisture and all organic constituents at 600 °C in a VULCAN™ furnace model 3–1750 (Cole-Parmer, IL 60061 United States). The weight of the residue after incineration was recorded as the Ash content.

2.2.2.3. Protein content determination. This was determined by Kjeldahl method using Kjeltec™ model 2300, as described in FOSS (2003). The method involved digestion of the sample at 420 °C for 1 h to liberate the organically-bound nitrogen in the form of ammonium sulphate. The ammonia in the digest (ammonium sulphate) was then distilled off into a boric acid receiver solution, and then titrated with standard Hydrochloric acid. A conversion factor of 6.25 was used to convert from total nitrogen to percentage crude protein.

2.2.2.4. Starch and sugar content determination. The method of Dubois, Gilles, Hamilton, Rebers, and Smith (1956) was used for the starch and sugar determination. This involved weighing of 0.2 g of the sample into a centrifuge tube with 1 ml of ethanol (0.789 g/ml), 2 ml of distilled water and 10 ml of hot ethanol. Then mixture was vortexed and centrifuged for 10 min at 2000 rpm using Sorvall centrifuge (Newtown, Conneticut, USA), model GLC-1. The supernatant was decanted into another centrifuge tube; this was used for sugar determination while the sediment was used for starch determination. Perchloric acid (7.5 ml) was added to the sediment and allowed to stand for 1 h; then 17.5 ml of distilled water was added to it and vortexed. An aliquot of 0.05 ml of the solution was pipetted into a test tube, 0.95 ml of distilled water, 0.5 ml of phenol, and 2.5 ml of H_2SO_4 were added and vortexed. The mixture was cooled at room temperature and the absorbance read on a spectrophotometer (Milton Roy Company, USA), model spectronic 601 already standardized at 490 nm wavelength. The absorbance of both starch and sugar was read at 490 nm.

2.2.2.5. Amylose content determination. This was determined using the method described by Williams, Wu, Tsai, and Bates (1958). This is a spectrophotometric method based on the formation of deep blue-coloured complex with iodine, the absorbance of which is read at 620 nm.

2.2.3. Determination of pasting properties

Pasting characteristics was determined with a Rapid Visco Analyser (RVA), (model RVA 3D+, Newport Scientific, Warriewood NSW, Australia). Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998, p. 26).