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Effect of harvesting periods on the chemical and pasting properties of trifoliate yam flour

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ABSTRACT

The effects of delayed harvesting on the chemical and pasting properties of trifoliate yam flour were studied. The tubers were harvested at 7, 8, 9, 10 and 11 months after maturity and were processed into flours. Chemical and pasting properties of the flours were determined. White trifoliate yam flour at 11 months was significantly different ($p < 0.05$) from other flours in dry matter and fibre contents but the lignin content (1.83%) was not significant different ($p > 0.05$) from yellow trifoliate yam flour at 11 months. Amylose and starch contents decreased while the sugar contents increased with harvesting periods. Yellow trifoliate yam flour had higher amylose at 10 months while the white trifoliate yam flour had higher starch at 9 months and sugar contents at 11 months. Potassium and sodium were the major minerals found in the yam with higher values in yellow trifoliate yam flours. Peak viscosity and breakdown decreased while the holding strength and final viscosities increased with harvesting periods. Harvesting trifoliate yam tubers at 7–9 months produced flour with high quality and prevents post harvest losses.

1. Introduction

Yam belongs to the genus *Dioscorea* (Family *Dioscoreaceae)* and is the second most important tropical root crop in West Africa, next to cassava (Opara, 1999). It is an important food in many tropical countries particularly in West Africa, South Asia and Caribbean, where it also has a social and cultural importance for about 300 million people throughout the world (Ettien et al., 2009). The varieties of yams grown in Nigeria are recognised by the range and colour of their leaves and tubers as well as by the direction of their stem twinning as they climb (Okigbo & Nwakammah, 2005). The genus *Dioscorea* includes about 600 species of which only six species are cultivated and consumed in Nigeria (Ike & Inoni, 2006; Okigbo, 2004). The cultivated species in Nigeria are the *Dioscorea rotundata* (White guinea yam), *Dioscorea cayenensis*, (Yellow guinea yam), *Dioscorea dumetorum* (trifoliate yam), *Dioscorea bulbifera* (aerial yam), *Dioscorea esculenta* (Chinese yam) and *Dioscorea alata* (water yam) (Ike & Inoni, 2006; Okigbo, 2004).

Trifoliate yam (*D. dumetorum*) is a lesser known yam among the yam species and is underutilized. Trifoliate yam tubers are known as three leaved yam, bitter yam and cluster yam. The plant is easily identifiable by its trifoliate compound leaf which twines in anticlockwise direction. The tubers are eaten during the time of famine or scarcity and are usually boiled with peel and eaten as boiled yam. Nutritionally, the tuber is superior to the commonly consumed yams, having high protein and mineral content (Martin, Treche, Noubi, Agbor, & Gwangwa, 1983).

Trifoliate yam tubers harden within 48 h after harvest and render them unsuitable for human consumption, even after long cooking (Afoakwa & Sefa-Dedeh, 2001). Only freshly collected tubers can be consumed locally and technological transformation of *D. dumetorum* was reported to be carried out promptly after harvest (Brillouet, Treche, & Sealy, 1981). Due to this reason, the tubers are left in the soil and harvested when needed for food. Although, the chemical, anti-nutritional, biochemical changes occurring during growth and storage of the tuber had been studied (Afoakwa & Sefa-Dedeh, 2001; Afoakwa & Sefa-Dedeh, 2002; Medoua, Mbome, Agbor-Egbe, & Mbofung, 2005a, 2007; Treche & Agbor-Egbe, 1996), but there is dearth of information on the effect of keeping the yam tubers in the ground after maturity. However, methods of storing yam tubers had been reported to vary from delayed harvesting, storage in simple piles or clamps to storage in buildings specially designed for that purpose, and application of sophisticated modern techniques (Igbeka, 1985; Ofor, Oparaeke, & Ibeawuchi, 2010). Ofor et al. (2010) reported losses in yam tubers stored using traditional methods as a result of uncontrolled temperature conditions thereby increasing the rate of respiration in the yam. However, the effect of delayed harvesting on the chemical and pasting properties of trifoliate yam flour is necessary as these enable us to know the changes occurring in the yam flours during these periods. Processing of

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trifoliate yam into flour curbs wastage, boost utilisation and improve the economic values of the yam. This paper aimed at comparing the effect of delayed harvesting on the chemical and pasting properties of flours from the two major cultivars (yellow and white) of trifoliate yam.

2. Materials and methods

2.1. Materials

The trifoliate yam setts of two cultivars (white and yellow) were collected from Esa-Oke farm settlements, Osun State, Nigeria.

2.2. Methods

2.2.1. Samples preparation

Trifoliate yam setts weighing 850–900 g were planted in mounds with 10 per row and spacing of 1 × 1 m on a plot of land. Thirty samples were planted per each cultivar. The planting was done on 20th March 2010 and sprouting of some of the yam setts occurred on 26th of April 2010. These trifoliate yam setts were marked and used for the study. The plot of land was weeded manually at a month interval after planting. There was no application of chemicals such as fertiliser, pest control or herbicides. The yam tubers were harvested at 7, 8, 9, 10 and 11 months after maturity starting from November 26th 2010–March 26th 2011. The experiment was repeated in November 20th 2011–March 20th 2012.

2.2.2. Preparation of flour

The freshly harvested yam tuber was washed, drained and peeled. The peeled tuber was sliced and dried in the hot air oven at 60 °C for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 μm sieve size. The flour samples were sealed in polythene bag.

2.2.3. Dry matter content determination

This was carried out by using the procedure of A.O.A.C method 925.09 (1990). The moisture cans were cleaned and dried in oven for one hour at 100 °C and were allowed to cool in the dessicator for 45 min. Then 5 g of sample were weighed in the dried moisture can. The cans were placed in oven overnight for 22–24 h at 105 °C. The sample cans were removed in oven and cooled in dessicator for 45 min and weighed.

$$\%\,\mathrm{MC} = \frac{\text{Initial weight of can} + \text{sample} - \text{final weight of can} + \text{sample}}{\text{Sample weight}} \times 100$$

$$\text{Dry matter } (\%) = 100 - \mathrm{MC}$$

2.2.4. Ash content determination

This was carried out by using the procedure of A.O.A.C method 923.03 (1990). The crucible used were dried in oven for one hour at 100 °C and allowed to cool in the dessicator. Then 3 g of sample were weighed into the dried weighed crucible. The crucible was placed in hot plate for one hour in order to burn the sample. The crucible was then transferred into the muffle furnance for six hours at 600 °C. The sample was removed in furnace, cooled in dessicator and weighed.

$$\%\,\text{Ash} = \frac{\text{Weight of empty crucible} + \text{sample} - \text{weight after ashing}}{\text{Sample weight}} \times 100$$

2.2.5. Crude fibre determination

Sample (1 g) was weighed into 500 ml flask and 100 ml of TCA digestion reagent were added. This was allowed to boil and reflux for exactly 40 min counting from the time boiling started. The flask was removed from the heater, cooled a little bit and filtered through no. 4 Whatman filter paper of known weight. The residue was washed six times with hot water and once with industrial spirit. The filter paper was folded and put in porcelain dish of known weight. It was dried overnight at 105 °C in the oven. This was removed, cooled in the dessicator for 45 min and weight was recorded. The sample and filter paper in the dish were burnt on hot plate for about one hour before transferring to muffle furnance at 600 °C for 5 h. After ashing the dish was cooled in the dessicator and weighed (AOAC method 962.09E, 1990).

$$\%\ \text{Crude fibre} = \text{Different in weight} \times 100$$

2.2.6. Determination of lignin

Flour sample (2.5 g) were treated four times with 25 ml 1% (v/v) 11 N HCl in methanol for 1 h under continuous stirring and centrifuged at 2000 rpm for 10 min. The residue obtained was then mixed with 100 ml of 12 M sulfuric acid and hydrolyzed for 3 h at ambient temperature under stirring. The solution was then diluted with distilled water to obtain 1 M H_2SO_4, and heated at 100 °C for 2.5 h with continuous shaking, cooled, vacuum filtered through an acid-treated 0.45 μm Millipore HVLP filter, and rinsed with hot distilled water and acetone. The filter containing lignin was air-dried at 60 °C overnight and weighed. Results were expressed as g lignin per 100 g sample dry weight (Medoua, Mbome, Agbor-Egbe & Mbofung, 2005b) and converted to percentage ligin.

2.2.7. Mineral contents

Flour sample (0.5 g) was weighed into a clean ceramic crucible. A blank was prepared with empty crucible. The crucible was placed in a muffle furnace at 500 °C for 4 h. The sample was allowed to cool down in the oven after which it was removed carefully. The ashed sample was poured into already labelled 50 ml centrifuge tube. The crucible was rinsed with 5 ml of distilled water into the centrifuge tube. The crucible was rinsed again with 5 ml of aqua regia. This was repeated to make a total volume of 20 ml. The sample was mixed properly and centrifuged (IEC Centra GP8) for 10 min at 301.86 g. The supernatant was decanted into clean vials for mineral determination. The absorbance was read on atomic absorption spectrophotometer (Buck Scientific Model 200A) at different wavelength for each mineral element (Cu-324.8, Zn-213.9, Ca-422.7, Fe-248.3, Mg-285.2, Mn-279.5, Na-589 and K-766.5 nm) (Novozamsky, Houba, Van, & Van, 1983).

2.2.8. Amylose content

Flour sample (0.1 g) was weighed into 50 ml test tube and 1 ml of 95% ethanol was added to wet and disperse the sample. Subsequently, 9.0 ml of 1 N NaOH was added and the test tube was heated in a boiling water bath for 10 min to solubilize the sample. From the solution, 1 ml was pipetted and made up to 10 ml with distilled water in another test tube while 0.5 ml aliquot was drawn into another test tube from this solution and assayed by the addition of 0.1 ml 1 N acetic acid and 0.2 ml of iodine solution to allow colour development The solution was diluted to 10 ml with distilled water, vortexed and left for 20 min for colour development after which the absorbance was read on a spectrophotometer (Milton Roy Spectronic 601) at 620 nm (Juliano, 1971).

A calibration curve was obtained from different solutions of amylose concentrations using corn amylose. Concentration factor (F) was obtained from the curve and amylose content was calculated as follows: