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Effect of delayed harvesting and pre-treatment methods on the antinutritional contents of trifoliate yam flour

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ABSTRACT

Effects of delayed harvesting and pre-treatment methods on the anti-nutritional contents of trifoliate yam flour were examined. Trifoliate yam tubers were washed, peeled, sliced and subjected to pre-treatment methods, such as soaking, pre-cooking and blanching/soaking. The phenols, phytate, oxalate, tannin and alkaloid profiles of the flours were evaluated and the values of phenols, tannin, oxalate and phytate contents were 0.02–0.32, 0.04–0.53, 0.11–4.32 and 0.20–1.05 mg/100 g, respectively. The predominant alkaloids in trifoliate yam flour were dioscorine and dihydrodioscorine. The white trifoliate yam flour had higher levels of anti-nutrients than the yellow trifoliate yam flour. Alkaloid contents of trifoliate yam flour increased slightly with delayed harvesting periods. Blanching/soaking method drastically reduced the anti-nutrient contents of trifoliate yam flour than other methods.

1. Introduction

Dioscorea dumetorum Pax (family *Dioscoreaceae*) is commonly known as bitter yam or cluster yam. It originated wildly throughout Africa, predominantly in the tropics (Nimenibo–Uadia, 2003) and occurs in both wild and cultivated forms. Yam tubers are known to contain different toxic substances that affect both human and animals when they are consumed, despite their high nutritional values (Polycarp, Afoakwa, Budu, & Otoo, 2012). The antinutritional factors in yam include phenol, tannin, oxalate, phytate and alkaloids. The bitter tastes in some yam tubers have been attributed to high tannin content and the major disadvantage of phenolic compound is the browning reactions that cause undesirable darkening of the tuber when cut and exposed to the atmosphere (Ngoddy & Onuoha, 1985). The degree of browning is proportional to the amount of polyphenol oxidase activity (Ngoddy & Onuoha, 1985). Oxalate occurs primarily in form of soluble oxalate, insoluble calcium oxalate (raphides), or a combination of the two forms (Libert & Franceschi, 1987). The intense irritation of the skin and mucous membrane (e.g. in the mouth) when they come in contact with mucilage is due to the presence of calcium oxalate crystals (raphide) which are thought to be the most obvious toxicant in yams (Sakai, 1983). Phytic acids is a hexaphosphate derivative of inositol, it is insoluble and it is not absorbed by humans intestinal mucous because of lack of endogenous enzymes system, such as phytase in humans and monogastic animals (Osagie 1992). Phytates bind minerals in the gastrointestinal tract, making dietary minerals unavailable for absorption and utilization by the body (Plaami, 1997). The alkaloids level may vary depending on cultivated species and cultural practices. At low level they impact bitterness to the tuber tissue and at high level, as found in some wild species, they can cause burning sensation in the mouth and throat, vomiting and diarrhea (Oke, 1985). Oke (1985) reported further that severe cases of alkaloid poisoning can cause general paralysis of the central nervous system, which can also result in seizures and convulsion. Alkaloids are water soluble and must be disipitated by boiling or soaking in water. These alkaloids are used in the pharmaticeutical industries for the production of steroids, heart stimulant, shampoo, a cure for snake bites, insecticides, etc (Oke, 1985). The antinutritional contents of food are significantly affected by age, cultivar, the geographic locality of the plant and storage condition after harvesting (Polycarp et al., 2012; Yang & Lin, 2008). The antinutritional composition of trifoliate yam tubers contributed greatly to the under-utilization of the yam coupled with the hardening process undergone after harvesting. The tubers are not harvested and stored like other yam species but are left in the ground after maturity until they are needed as food. The effects of delayed harvesting and pre-treatments methods on the anti-nutritional contents of trifoliate yam have not been widely studied. However, various methods of reducing anti-nutritional contents of

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yam have been studied (Bhandari & Kawabata, 2006; Ezeocha, Ojimelukwe, & Onwuka, 2012; Medoua, Mbome, Agbor-Egbe, & Mbofung, 2007; Shanthakumari, Mohan, & Britto, 2008; Wanasundera & Ravindran, 1992). Therefore, the present paper reports the effect of delayed harvesting and pretreatment methods on the anti-nutritional composition of trifoliate yam flour. This study is necessary to give information on the levels of anti-nutrients at different harvesting periods and how to reduce them for human consumption. This information would aid processing of trifoliate yam into flour thereby improving the utilization of the yam and reducing wastage of the crop during its season.

2. Materials and methods

2.1. Materials

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

2.2. 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 kept weed-free manually at a month interval after planting. There was no application of chemicals of any kind applied either as fertilizer, pest control or herbicides. The yam tubers were harvested in a month interval starting from November 26th 2010 to March 26th 2011. The experiment was repeated in November 2011 to March 2012.

2.3. Preparation of raw flour

The freshly harvested yam tubers were washed, drained and peeled. The peeled tubers were 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.

2.4. Preparation of soaked raw flour

The freshly harvested yam tubers were washed, drained and peeled. The peeled tubers were diced, soaked in water for 1 h 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.

2.5. Preparation of blanched/soaked flour samples

The freshly harvested yam tubers were washed, drained and peeled. The peeled tubers were diced, blanched (60 °C) for 10 min in water bath, soaked for 12 h and dried in the oven (60 °C) for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 μm sieve size.

2.6. Preparation of pre-cooked samples

The freshly harvested yam tubers were washed, peeled, diced and pre-cooked for 10 min in water bath maintained at 100 ± 2 °C. The samples were dried in an oven set at 60 °C for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 μm sieve size.

2.7. Tannin determination

Milled samples (200 g) was extracted in 10 ml 70% aqueous acetone for 2 h at 30 °C in a water bath. A Gallenkamp orbital shaker at 120 rpm was used. Diethyl ether containing 1% acetic acid was used to extract the fats and the pigments in the sample. Tannin was then determined as total phenols in 0.05 ml aliquot in test-tubes by the addition of distilled water to 1 ml mark and the addition of 0.5 ml Folin Ciocalteau reagent (Sigma) and 2.5 ml sodium carbonate. The absorbance of the solution was measured at 725 nm after 40 min using the method of Makkar & Goodchild (1996). The tannin equivalent in the form of phenol will be calculated from a standard curve.

2.8. Phytate determination

The phytin content was quantified by adding 8 g of the milled sample soaked into 200 ml of 2% HCl and allowed to stand for 3 h. The extract was filtered through a double layer filter paper and 50 ml of the duplicate samples of the filtrate was pipette into 400 ml beaker. Ammonium thiocyanate (0.3%w/v) (10 ml) was used as an indicator and distilled water (107 ml) was added to obtain a pH of 4.5. Ferrous chloride solution containing 0.00195 gm Fe/ml was titrated against the solution of the tests samples until a brownish yellow colouration persisted for 5 min. Phytin phosphorous was determined using the relationship that each milligram of iron is equivalent to 1.19 mg of phytin phosphorous. The phytin content was calculated by multiplying by a factor of 3.55 according to Dairo (2008).

2.9. Oxalate determination

Oxalate content was determined using the method of Nwinnuka, Ibeh & Ekeke (2005). The flour sample (1.0 g) was extracted thrice by warming (40–50 °C) and stirring with a magnetic stirrer for 1 h with 20 ml of 0.3 N HCl. The combined extracts was diluted to 100 ml with water and used for the total oxalate estimation. About 5 ml of each extract was made alkaline with 1 ml of 5 N NH_4OH. This was then made acidic with glacial acetic acid and phenolphthalein indicator (2–3 drops) was added, excess decolourizes. Then, 1 ml of 5% calcium chloride was added and the mixture was allowed to stand for 3 h after which it was centrifuged (IEC Centra GP8) at 140.868 g for 15 min. The supernatant was discarded while the precipitate was washed thrice with hot water, with thorough mixing and centrifuging each time. Then, to each tube, 2 ml of 3 N H_2SO_4 was added and the precipitate was dissolved by warming in a water bath at 70–80 °C for 30 min. The content of each tube was titrated with freshly prepared 0.01 N potassium permanganate solution. Titration was done at room temperature (29 °C) until the first pink colour appeared throughout the solution. The solution was allowed to stand until it was colourless. It was warmed to 70–80 °C and titration continued until a pink colour persisted for at least 30 s.

$$\%\ Oxalate = \frac{W \times 100}{5}$$

W = Mass of oxalate in 100 ml of extract.

2.10. Determination of total phenol

The sample (5 g) was boiled with a 50 ml of ether for 14 min. 5 ml of the extract was pipette into a 50 ml flask, then 10 ml of distilled water was added. 2 ml of ammonium hydroxide solution and 5 ml of concentrated amyl-alcohol were also added. The sample was made up to mark and left to react for 30 min for colour