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CHEMICAL, FUNCTIONAL AND PASTING PROPERTIES OF STARCH EXTRACTED FROM THREE VARIETIES OF YAM COMMERCIALLY AVAILABLE IN ILARO METROPOLIS

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ABSTRACT

This study evaluated the Chemical, Functional and Pasting properties of starch extracted from three varieties of yams using standard analytical methods. Analysis revealed that significant differences exists in Moisture content, Crude fat, Protein, Ash, Carbohydrate, energy as well as amylose. The moisture contents ranged from 5.16 – 7.81%; Protein varied from 5.25- 21.7%; pH ranged from 5.82- 7.48; Fibre ranged from 2.38-2.50%; Ash varied from 3.10-3.65%; Carbohydrate ranged from 64.73- 77.50%; Energy varied from 1514-1553Kcal/100g and Amylose content, ranged from 18.23-35.58 respectively. Also, functional properties showed significant difference ($p \leq 0.5$) among starch samples as the bulk densities, dispersibilities, water and oil absorption capacities, wettability and gelatinization temperature varied greatly. The peak viscosity ranged from 2492-5980 RVU; Trough viscosity varied between 2082 and 3472 RVU; Breakdown viscosity varied from 410-2308 RVU while the setback viscosity was from 261-3715 RVU. The peak time in minutes ranged from 4.93-7.00 minutes while pasting temperature varied from 81.65- 90.58 ^{0}C. However, knowledge on chemical, functional and pasting characteristics of starches from three varieties of yam as evaluated in this study can provide useful information to end users, both domestically and industrially.

Keywords: Chemical, Functional, Pasting Properties, Starch, Yam.

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INTRODUCTION

Roots and tubers belong to the class of crops that provides energy in the human diet in the form of carbohydrate. Root crops especially cassava and yam are important commodities in the diet in many parts of Africa. Their processing involves treatment that converts them into finished products with acceptable taste, color, flavor, and texture (Sefa- Dedah, 1995). Yam is the common name for some plant species in the genus *Dioscorea* (Family *Dioscoreaceae)* that form edible food. They are grown widely in Tropical regions of the world and contain 70-80% of moisture, 16-24% of starch and trace quantity of protein and lipids (Huang, Lin and Wang, 2006).

Nigeria produces 60% of world yam annually, producing an average of 31million metric tons (Bergh, Orozco, Gugerty and Anderson, 2012), although Food and Agriculture Organization (FAO) estimates showed the annual production to be above 37million metric tons (FAOSTAT, 2013). Yam's richness in carbohydrate especially starch consequently has multiparty end use. It is often processed into flour for use in the preparation of paste and its uses as an industrial starch has also been established as the quality of the some of the species is able to provide as much as starch as in cereals (Izekor and Olumese, 2010).

Starch is a polysaccharide that is majorly available in plants as storage carbohydrate and a major component of root and tuber crops. It is deposited in partially crystalline forms ranging in morphology and structure between and within plant species (Blazek and Copeland, 2008). The digestibility and structure of starchy food is known to be altered by cooking method which in turn could influence glycemic response (Glen, Amogh, Thomas and Wolever, 2005).

According to literature, different researches have been carried out in yam starches. Akinoso and Abiodun (2013) studied the effect of harvest in the periods the morphology and physico-chemical properties of trifoliate yam starches while Amani, Kamenan and Colonna (2002) researched into the variability in starch physico-chemical and functional properties of yam cultivated in Ivory Coast. Also Hoover (2001) reviewed the composition, molecular structure and physico- chemical properties of tuber and root starches, and Oledinma (2009) studied the evaluation of the pasting and some functional properties of aerial yam was carried out by Prince-Will and Eze-mbaukwu (2015) while the physico- chemical and pasting characteristics of flour and starch from aerial yam was reported by Sanful and Enymann (2016). However, this present work aimed at evaluating the chemical, functional and pasting properties of starch extracted from three varieties of yams commercially available in Ilaro metropolis.

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MATERIALS AND METHODS

Source of materials

Three varieties of fresh diseased free yam: white yam, yellow yam and water yam were obtained from a local market in Ilaro metropolis. They were transported n polythene bags to the laboratories of Department of Food Technology, Federal Polytechnic Ilaro for further processing and analyses. All reagents and chemical used were of analytical grade.

Production of yam starch

The wet extraction method described by Sanful and Engmann (2010) was used for the starch extraction. The bulbs were washed, peeled, chopped into smaller pieces to facilitate grating. After peeling and grating. The samples were milling into a pulp. The pulp was collected into a cheese cloth in a colander mounted over a bucket and vigorously washed with water by hand. The fibre was squeezed to drain out the starch milk into the bucket. After settling of starch, the supernatant was decanted and the wet starch open-air-dried for 48 hours and blended to a fine powder and stored for analysis.

ANALYTICAL PROCEDURES

Functional properties

Bulk density

The method of Onwuka (2005) was used. Bulk densities of starch samples were determined by weighing 50g sample into 100ml graduated cylinder, then tapping the bottom ten times against the palm of the hand and expressing the final volume as g/ml

Water and oil absorption capacity

One gram (1g) of each sample was weighed into a conical graduated centrifuge tube. Using a warring mixer, the samples were mixed thoroughly with 10ml distilled water for 30 sec. The samples were removed and allowed to stand for 30min at room temperature and centrifuged at 5000Xg for 30 min. the volume of free water or oil (the supernatant) was read directly from the graduated tube calculation. The amount of oil or water absorbed (total minus free) was multiplied by IPS density for conversion to grams (Onwuka, 2005)

Wettability

The wettability was determined by Onwuka (2005) method. The starch sample (1g) was added to a 25 ml graduated cylinder with a diameter of 1cm. A finger was then placed over the open end of the cylinder. It was inverted and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The finger was then removed of allow to allow the test material to be clumped. The wettability is the time required for the sample to become completely wet.

Gelation Capacity

The method by Onwuka (2005) was adopted. A starch sample suspension of 2.20% (w/v) in 5ml of distilled water was prepared in test tubes. The samples were heated for 1hr in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were then cooled further for 2hr at 4^0 C. the gelation capacity in the least concentration determined as the concentration when the sample from the inverted test tube will not fall or slip.

Swelling Index

One gram (1g) of the starch was weighed into 10ml measuring cylinder and the volume it occupied was recorded as (V1). Distilled water was added until the 10ml mark was reached. The cylinder containing the sample was left to stand for 45min after which the new volume (V2) was recorded. The swelling index was expressed as the ratio of the final over the initial volume (Ojinaka, Ebinyasi, Iheweje and Okorie, 2014).

Chemical Properties

The starch samples were analyzed for moisture, ash, fibre, protein and fat contents according to the method of AOAC (2000). Carbohydrate content was calculated by difference.

Determination of Amylose Content

Amylose content was determined with the method Juliano (1971). Exactly, 0.1g (100mg) of starches were weighed into a 10ml volumetric flask and 1ml of 99.7- 100% (v/v) ethanol and 9ml of 1N- Sodium hydroxide (NaOH) were carefully added, the mouth of the flask was then covered with foil and the content mixed well. The samples were heated for 10min in a boiling water to gelatinize the starch (the timing started when the boiling began). The samples then removed from the water bath and allowed to cool very well. It was then filled up to the mark with distilled water and shaken well. About 5ml of the mixture was then pipetted into another 100ml volumetric flask. Acetic acid (1N, 1.0ml), and 2ml of iodine solution were added and top to mark with distilled water. Absorbance (A) was read using spectrophotometer at 620 nm wavelength. The blank contained 1ml of ethanol, 9ml of NaOH, and the boiled and top up to the mark with distilled water. 5ml was then pipetted into 100ml volumetric Flask. Approximately, 1ml of Acetic acid and @ml of iodine solution was added and then filled to mark, this was used to standardize the spectrophotometer at 620nm. Amylose content was estimated thus;

Amylose content (%) = (3.06) (A) (20) = 61.20 (A)

pH Determination

Ten gram (10g) of starch sample was weight and dissolved in a breaker containing 25ml of distilled water to form slurry. It was allowed to stand for 10 min with constant stirring. The pH was taken with pH meter (R1-02895 HANNA/ Italy).

Energy Value Determination

The energy content was calculated using the Atwater Calorie conversion Factor: 4 Kcal/100g of carbohydrate, 9 kcal/100g of fat and 4 kcal/100g of protein (FAO/WHO, 2003).

Pasting Properties

Pasting characteristics of yam starch were determined with a Rapid Visco Analyser (RVA Super 3, Newpost Scientific Pty Ltd., Australia) by Newpost Scientific (1998). Three grams (3g) of starch was mixed in 25ml of water in a sample canister. The sample was thoroughly mixed and fitted into the RVA as recommended by Newpost Scientific (1998). With the use of the 12- min profile, the slurry was heated from 50^0 C to 95^0 C with a holding time of 2min. this was followed by cooling to 50^0C with another 2min holding time. Both the heating and cooling was at a constant rate of 11.25^0C/min with constant shear at 160rpm. Corresponding values for peak viscosity, holding strength breakdown, final viscosity, setback, pasting time and pasting temperature from the pasting profile were read in a computer connected to the RVA.

Statistical Analysis

All data obtained from the analysis were subjected to analysis of variance (ANOVA) using SPSS software package. Means were separated using Duncan Multiple Range Test to determine the significant difference at 5% probability level.

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RESULTS AND DISCUSSION

Table 1: Chemical Composition of Starch from Three Varieties of Yam Commercially Available in Ilaro Metropolis

Samples	Moisture Content (%)	Crude Protein (%)	pH	Crude Fat (%)	Crude Fibre (%)	Total Ash (%)	CHO (%)	Energy	Amylose (%)	Amylopectin (%)
Bitter Yam	5.16 ± 0.25^{cd}	21.7 ± 90.28^{c}	5.83 ± 0.06^{a}	2.84 ± 0.11^{ab}	2.38 ± 0.58^{bc}	3.10 ± 0.30^{ab}	64.73 ± 0.00^{a}	1553.5 ± 1.32^{ab}	18.23 ± 0.00^{a}	81.77 ± 0.00^{a}
Water Yam	6.72 ± 0.07^{ab}	5.25 ± 0.04^{a}	7.48 ± 0.14^{ab}	3.88 ± 0.01^{a}	2.45 ± 0.66^{ab}	4.20 ± 0.00^{a}	77.50 ± 0.08^{ab}	1529.6 ± 0.00^{a}	35.58 ± 0.14^{ab}	54.45 ± 0.00^{a}
White Yam	7.81 ± 0.13^{bc}	7.88 ± 0.13^{ab}	5.82 ± 0.08^{bc}	3.88 ± 0.01^{a}	2.50 ± 0.03^{a}	3.65 ± 0.00^{a}	74.28 ± 0.00^{a}	1514.7 ± 0.00^{a}	24.34 ± 0.57^{bc}	75.61 ± 0.00^{a}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$)

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Table 2: Functional Properties of Starch from Three Varieties of Yam Commercially Available in Ilaro Metropolis

Samples	BD(g/ml)	DIS (%)	WAC (g/g)	OAC (g/g)	WETT (Secs)	Gelatinization Temp (º C)
Bitter Yam	13.10 ± 0.14^{ab}	46.50 ± 0.17^{a}	2.15 ± 0.01^{a}	2.75 ± 0.07^{a}	6.24 ± 0.15^{a}	95.00 ± 0.00^{bc}
Water Yam	11.85 ± 0.92^{bc}	72.00 ± 1.41^{b}	1.90 ± 0.00^{b}	2.08 ± 0.07^{a}	6.26 ± 0.06^{bc}	96.50 ± 0.71^{a}
White Yam	12.75 ± 1.06^{cd}	77.50 ± 0.71^{c}	2.11 ± 0.01^{bc}	2.20 ± 0.14^{bc}	5.12 ± 0.73^{c}	98.10 ± 0.00^{ab}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$).

BD: Bulk Density, DIS: Dispersibility, WAC: Water absorption capacity, OAC: Oil absorption capacity, WETT: Wettability, Gelatinization Temp: Gelatinization Temperature.

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Table 3: Pasting Properties of Starch from Three Varieties of Yam Commercially Available in Ilaro Metropolis

Samples	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (mins)	Pasting Temp (º C)
Bitter Yam	2492.0±0.00[a]	2082.0±5.38[a]	410.0±4.34[a]	2343.0±2.83[a]	261.0±2.12a	6.60±0.85[a]	90.58±0.04[ab]
Water Yam	3062.0±4.81[b]	2978.0±4.24[b]	84.0±2.83[b]	2.777±2.83[b]	1017.0±0.00[b]	7.00±1.55[c]	85.60±0.28[b]
White Yam	5980.0±4.24[c]	3472.0±4.24[c]	2308.0±0.00[c]	7191.0±0.00[c]	3715.0±2.83[c]	4.93±0.04[c]	81.65±0.95[c]

Mean values with different superscripts within the same column are significantly different ($p < 0.05$)

DISCUSSION

Chemical properties

The results of the three varieties of yams commercially available in Ilaro metropolis are as shown in Table 1.

The moisture content of yam starch for the three samples ranged from 5.16 % - 7.81%. the starch obtained from white yam has highest moisture content while that of bitter yam has the least. Generally. The starches have low moisture contents and this was in agreement with those reported by Ashworth and Draper (1992) in a similar work. The lower the moisture content of the product to be stored, the better the storage ability. High moisture content can enhance microbial growth which leads to deterioration of foods (Akanbi, Nazamid, Adebowale, Farooq and Olaoye, 2011). The result of this study shows that all the three starches can stay longer in the shelf. Crude protein contents of 21.7 %, 5.25 % and 7.88 % were obtained for bitter, water and white yam starch samples. Significant differences were observed in the crude protein contents of the starch samples. The differences in terms of the protein contents could be due to their varieties and environmental differences, especially the soil where they are grown. Sanni, Adebowale, Maziya-Dixon (2008) reported in a previous work that gene and environmental interactions affects the nutritional composition of plant materials. There are also significant differences in the pH of the starch samples. Both Bitter yam and White yam had 5.83 and 5.82 pH values in contrast to 7.48 in water yam, indicating that water yam starches are more alkaline in nature. Yams are known to contain low amount of fats, hence values ranged from 2.84% - 3.88 % and this will enhance the storage life of the starch flours due to the lowered chance of rancid flavor development (Zakpa, Makmensah and Adubofour, 2010). Fibres play a very significant role in the prevention of several diseases such as constipation, irritable colon, cancer and diabetes (Slavin, 2005; Elleuch, Besbes, Blecker and Attia, 2011). The crude fibre for all the three starch samples are 2.38 %(Bitter yam), 2.45 %(water yam), and 2.50% (white yam) respectively. The ash contents of the starches are 3.10 %, 4.20% and 3.65% for bitter yam, water yam and white yam respectively. The values obtained showed that yams generally are rich in mineral contents. The major nutrient in yams being a starchy food is carbohydrate. Values varied from 64.73% - 74.28% for all the starch samples, indicating significant differences in their values. The difference could be due to the varieties differences, climate and soil characteristics, harvest time, storage time, and post-harvest processing according to Osagie (1992). The amylose contents for the starches varied from 18.2 % to 35.58% indicating significant differences among the starch samples. However, among the three varieties, starch produced from bitter yam had the lowest amylose content, indicating that when incorporated into fried products, swelling of the starch will be enhanced.

Functional Properties

Table 2 shows the functional properties of three varieties of yam commercially available in Ilaro metropolis. The bulk densities for the starches obtained from three yam varieties are 13.10 g/ml, 11.85 g/ml and 12.75g/ml for bitter, water and white yams respectively. It was observed that starch from bitter yam had the highest bulk density while water yam had the lowest value.

Functional properties are have defined as those parameter that determine the application and use of food materials for various food products. It has been reported that bulk density is influenced by particle size and density of the flour and it is important in determining the packaging requirements and material handling (Karuna, Noel and Dilip, 1996). Bulk density is a also measure of heaviness of a flour (Starch sample, which indicates that the relative volume of the flour is a package will not reduce excessively during storage. The dispersibility ranged from 46.50% to 77.50% for the sample. Dispersibility is a measure of the reconstituability of flour or flour binds in water. According to literature, the higer the dispersibility the better the floor reconstitutes in water (Kulkani, Noel and Kulkani, 1996). The starches obtained from both water yam and white yam have high dispersibilities compared bitter yam, implying that they will reconstitute easily to give a fine consistency dough during mixing as reported by Adebowale, Sanni & Onitilo, (2008). Water absorption capacity is an index of the ability of a flour product to associate with water under a condition where water is limiting. High water absorption capacity is attributed to loose structure of starch polymers while low values the compactness of the molecular structure. The three starches have water absorption capacities of 2.15g/g, 1.90g/g and 2.11g/g for bitter, water and white yams respectively. The oil absorption capacity is an important functional property in food formulations because fat improves the flavor and mouth feel of foods (Aremu, Olaofe and Akintayo, 2007). The oil absorption capacities for the three samples are low and this might be due to low hydrophobic proteins which shows superior binding of lipids. Wettability is the measure of the rate at which flour samples get wetted in water. The wettability varied from 5.12 sec to 6.26 sec, indicating the rate of water absorption which is also due to the structure and binding force of the starches. Significant differences ($p<0.05$) was observed in the gelatinization temperatures which ranged from 95.00^0C – 98.10^0C. the gelatinization temperatures in this present studies are very high, implying the usefulness of the yam starches for the production of the other food products such as extruded snacks and noodles.

Pasting properties

Results of the pasting characteristics of the starches obtained from three varieties of yam commercially available in Ilaro metropolis are as shown in table 3. Pasting properties are most of the most important properties that influence quality and aesthetics consideration in food industry, since they affect texture and digestibility as well as the end use of starch based food commodities (Onwulezo and Nnamuchi, 2009). Peak viscosity is an index of the ability of starch-based food to swell freely before their physical breakdown (Adebowale et al., 2008). It ranged from 2492.0 to 5980.0 RVU. The highest peak viscosity was recorded for starch produced from white yam while the least was recorded for bitter yam. According to Adeyemi and Idowu (1990), peak viscosity indicates the water binding capacity of flour samples and is important to the use in order to obtain a useable starch paste. The trough viscosity ranged from 2082.0 to 3472.0 RVU. High trough viscosity is an indication of the ability of the paste to withstand breakdown during cooling. Starch produced from white yam has the highest trough viscosity with that of bitter yam least trough viscosity. Breakdown viscosity indicates the ability of the starch to form a viscous paste or gel after boiling and cooling. The breakdown viscosity varied from 84.0 to 2308.0 RVU.

The higher the value, the greater the ability of the starches to withstand breakdown. The final viscosity which is the ability of the material to form a viscous paste or gel after cookig and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990) ranged from 2343.0 to 7191.0 RVU. According to Adeyemi and Idowu (1990), the setback viscosity has been correlated with texture of various products is also an index of the tendency of the cooked flour to harden on cooling due to amylose retrogradation. The setback viscosities as obtained for the three yam samples are 261.0 RVU, 1017.0RVU and 3715.0RVU respectively. Peak time which is a measure of the cooking time ranged from 4.93 – 7.00 minutes, with starch of water yam having the highest value of 7.00 minutes, suggesting more processing time while that of white yam has the least peak time of 4.93 minutes, indicating less processing time. The pasting temperatures recording for the three yam samples (Starches are 90.58 ^{O}C, 85.65 ^{o} C and 81.65 ^{O}C respectively). Pasting temperature gives an indication of the gelatinization time during process. It is the temperature at which the first detectable increase in viscosity is measured. The higher pasting temperature implies higher water binding capacity.

CONCLUSION

This study has shown that significant differences exists between different yam varieties in term of chemical, functional and pasting characteristics. Yams, being a starchy crop has not been fully used to a very significant extent, therefore, this study has provided baseline for increased utilization of the crop, either domestically or industrially.

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