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Full-Length Research Paper

Chemical and nutritional study of native starch from selected root crops and its industrial application

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ABSTRACT: Starch is a micro-constituent in many foods, and its chemical properties and nutritional interaction play an important role in determining how it is used. The goal of this study is to look at the chemical and nutritional properties of a variety of native starches derived from cassava, sweet potato, and cocoyam. The starch was extracted, refined using conventional methods, and sun dried. On the various samples, chemical (amylose, amylopectin, pH, total titratable acidity (TTA), and reducing sugar) and nutritional tests were performed (fat, protein, crude protein, ash and moisture). Amylose levels ranged from 15.04 % (Um37) to 18.755 % (pot), while amylopection levels ranged from 81.24% (Sweet Potato) to 84.9 % (pot) (Um37) Sweet potato had the highest reducing sugar (72.23 mg/100g) and Um 37 had the lowest (44.41 mg/100g). The starch samples had pH values ranging from 6.25-7.45, indicating that they were low acidity to low alkaline. TTA levels were highest in the sweet potato sample (pot = 0.11) and lowest in the cocoyam sample Ede (0.06), but all were within acceptable ranges for starch products. The moisture content of the starches varied according to botanical source, with cassava starch 419 having the highest (13.2 %) and cocoyam sample Nxs003 having the lowest (10.2 %). Sweet potato had the highest fat content of starch, pot-x-igbariam (0.22 %), and cassava sample um37 had the lowest (0.12 %). Protein content was highest in cassava starch sample 30572 (1.225%) and lowest in cassava starch sample um37 (0.169%). The ash content of the starches varied between 0.05 and 0.15 % (um37) (Nxs003). The ash content of cocoyam Nxs003 and cassava 419 (0.14 %) was comparable. Cassava sample 419 (0.11 %) contained the least crude fiber of the starches, while cocoyam sample Nxs contained the most (0.15%).

Keywords: Starch, amylose, amylopectin, acidity, nutrition

INTRODUCTION

Amylose (a linear polymer of a-D-glucose units linked by a-1,4 glycosidic linkages) and amylopectin (a branched polymer of a-D-glucose units linked by a-1,4 and a-1,6 glycosidic linkages) account for 98–99 % of the dry weight of starch (Almeida *et al*., 2013). These polymers have the same basic structure, but their length and degree of branching differ, influencing their physicochemical properties (Wani *et al*., 2014). The properties and interactions of starch, a micro-constituent of many foods, are of interest to both the food industry and human nutrition. Starch has been used in industrial products since ancient times (Falade and Okafor, 2013).

Starch is chosen for industrial applications based on its availability as well as its physicochemical properties, which vary depending on the source (Pascoal *et al*., 2013). Starch is currently used in the food industry as a food additive to control the consistency and texture of sauces and soups, to prevent gel breakdown during processing, and to extend the shelf life of an end product. in the laundry, fine fabric sizing, and skin cosmetics industries; in the paper industry to improve paper strength and printing properties; as a drug filler in the pharmaceutical industry; and as packaging binders (Falade and Okafor, 2013). Commercial starches, on the

other hand, are derived from wheat, rice, and tubers or roots such as cassava, potato, and cocoyam (Pérez-Pacheco *et al*., 2014).

The use of new starches, or starches isolated from non-traditional sources such as roots and tubers crops could provide options for extending the spectrum of desired functional properties required for the development of value-added food products (Pérez-Pacheco *et al*., 2014). With the industrial demand for new technological properties, several non-traditional starch sources with varying properties have been investigated due to an interest in using native starches for food production rather than chemically modified starches (Albano *et al*., 2014). Currently, these native starches are typically overlooked and discarded during the isolation and separation of small molecule bioactive ingredients, such as in garri processing (Yuan *et al*., 2007). A study of the chemical and nutritional constituents of native starches from various sources will provide valuable information for optimizing their industrial applications.

Furthermore, tubers and roots do not contain gluten, which is an important consideration when looking for a carbohydrate source. Using tubers as a source of starch instead of gluten-containing carbohydrate may help to reduce the prevalence of cardiovascular disease (Ariwaodo *et al*., 2017). The selection and use of starches in food products necessitates a basic understanding of starch properties (Moore *et al*., 1984). Today, there is a growing interest in native starches with distinct properties for use in foods in order to avoid the starch "modification" label statement. The purpose of this research is to evaluate the chemical and nutritional properties of starches derived from selected tubers, as well as to broaden our understanding of their applications in the food industry. Cassava (419, um 37, and 30572), sweet potato (x-igbariam), and cocoyam were the native starches studied in this study (ede-uhieand NX003).

MATERIALS AND METHODS

Source of materials

Matured roots of three cassava varieties (30572, 419, and umu 37), one sweet potato root (*x-igbariam*) and two cocoyam (*edeuhie* and NXS003) were obtained from National Root Crops Research Institute (NRCRI), Umudike and processed into starch within 24hrs after harvest. Chemicals and equipment used for the analysis were obtained from Crop Utilization Laboratory and Bio Science Laboratory of International Institute for Tropical Agriculture (IITA), Ibadan, and Central service laboratory of National Root Crops Research Institute Umudike and Department of Plant Science/Biotechnology (PSB) Post Graduate Laboratory of Micheal Okpara University of Agriculture, Umudike Abia State.

Processing of starch

The method described in Osunsani *et al.* (1989) with slight modification was used for the production of starch from cassava, sweet potato and cocoyam samples. Matured roots of cassava (30572, 419 and umu 37) sweet potato (x-*Igbariam*) and cocoyam (*edeuhie* and Nx003) were peeled and washed with clean water and allowed to drain. They were subsequently grated with locally fabricated grater. The pulp was placed on a muslin cloth, sieved and flushed with clean water until the starch stream ceases. The crude starch milk was kept in a refrigerator overnight. The supernatant was decanted leaving the precipitated starch (Figure 1).

Purification of starch

Exactly 1000ml of clean water was added to 300g of crude starch and stirred until all the starch was suspended in the water. The suspension was undisturbed until sedimentation ceased. The supernatant was decanted leaving the sediments in a plastic bucket. An equivalent volume of fresh clean water was added to the volume of the starch sediments and stirred until the starch was suspended in the water. The starch slurry was filtered through a muslin cloth and flushed with water. The filtrates were allowed to sediment for 20min and the supernatant decanted. This procedure was repeated two (2) times yielding clean starch cake.

Quality control of the starch

A teaspoonful sample was taken from the top of the clean starch cake sediment and dissolved in a 15ml of water in a test tube. The tube and its content were centrifuged for 20min at 2000 rpm and a small sample was drawn from the boundary between the liquid and the sediment using a pipette. Observation was done under a microscope (magnification x100). Absence of particles in the samples under observation confirmed its purity.

Drying and storage

The starch flakes were spread on a table and allowed to sundry for two days. They were pulverized with a milling machine (Thomas Wiley mill-model Ed-5, Philadelphia, USA 1982), stored in bottles and preserved in a refrigerator (Haier thermacool, model HRF-350,2001) (Ubalua, 2014).

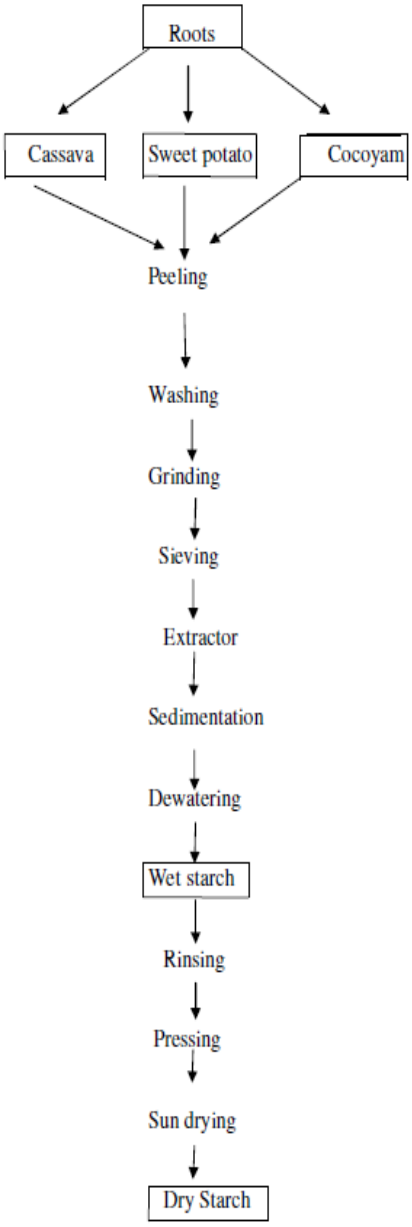


Figure1: Flow chart for production of starch from root crops

Starch yield

% starch was calculated on dry bases as:

$$\frac{\text{Weight of ground tuber - weight of starch} * 100}{\text{Weight of ground tuber}}$$

Amylose and amylopectin determination

The apparent amylose was determined by the amylose-iodine complex procedure with modification (Zhu *et al.,* 2008). The result was obtained using spectrophotometer (Shimadzu UV-170, Tokyo, Japan). The starch sample of 0.10g was suspended in a solution containing 1ml 99% (v/v) ethanol and 9ml of 1M NaOH and heated in a water bath at 95ºC for 10min. Then the starch solution was diluted with deionized water to 100mAbout 5ml of the solution was transferred into 100ml flask, 50ml deodorized water and 1ml Iodine solution was transferred at the same time. After that, the volume was made up to 100ml with deionized water. Exactly 5ml of 0.09M NaOH solution was transferred into another flask as a blank. Then the value of absorbance was obtained at 620nm. The experiments were performed in duplicate.
The amylase content expressed as % by mass on dry bases was obtained by referring the absorbance to the calibration graph of starch in dry bases.
Amylopectin was calculated as 100 - % Amylose contentl mark onconical flask.

pH Measurement

The pH values were determined using pH-meter (Corning pinnacle, Model 543i, Corning incorporated, USA). Starch samples (5g) were weighed in duplicate in a beaker, mixed with 20ml of distilled water. The suspension was stirred for 5min and left to settle for 10min. The pH of the water phase was measured using calibrated pH meter (pH 4.0 and pH 7.0) (Benesi, 2005).

Total titratable acidity (TTA)

The method used for the total titratable acidity of starch samples was described by AOAC (1990). Two (2) grams of the sample were weighed into conical flask and allowed to stand for 2h, filtered (optional) and drops of phenolphthalein indicator added followed by shaking to mix well. This was titrated against alkaline solution of O.IN NaOH. Faint pink colour indicated end point. This was done in duplicate.

$$\text{The result was calculated as. \% TTA} = \frac{T \times N}{V} \times \frac{100}{1}$$

V= volume of sample titrated
T= titre value obtained from titration
N=Normality of titrate (0.IN)

Reducing sugar

The method of AOAC (1990) was used for determination

of reducing sugar in the starch samples. Exactly 0.1g of sample was weighed and extracted with 5ml hot 80% ethanol (twice). The supernatant was collected extracted and evaporated in a water bath at 80ºC for 30min. Exactly 10ml of distilled water was added. About 0.5ml, 1ml, 1.5ml, and 3ml of the extract were pipette in six test tubes and 4ml of distilled water was added in all the tubes. Three millilitre (3ml) of DNS reagent was added, heated in water bath for 5min and 1ml of 40% Rochelle salt added. The intensity of dark red colour formed was read at absorbance of 510nm.

Preparation of glucose standard for reducing sugar

Exactly 100, 200, 300, 400, and 500µg of glucose was collected and 3ml of distilled water add to each, the 3ml of DNS reagent was added and boiled for 5mins. When content of the test tube was warm, about 1ml of 40% Rochelle salt solution was added and allowed to cool. The absorbance was read at 510nm.

The amount of reducing sugar was calculated using this equation:
$Y = mx + c$

Where Y =absorbance, c = concentration, m = slop of the standard graph

Statistical analysis

Data obtained in the study were analyzed using the analysis of variance (ANOVA) at the significant level of 5% ($p \leq 0.05$) using SPSS 20 (analytical software). Statistical differences were found using least significant difference (LSD) at the 5% significant levels.

RESULTS AND DISCUSSION

Nutritional composition of starches

(Table 1) shows the results of an analysis of starch moisture, ash, fat, crude fiber, and carbohydrate content. The moisture content of the starches varied depending on the botanical source, with cassava starch 419 having the highest (13.2 %) and cocoyam sample Nxs003 having the lowest (10.2 %). Mweta *et al*. (2008) reported a moisture content range of 0.42-11.3 % for cocoyam and cassava starch. Sweet potatoes' low moisture content makes them easy to store at room temperature and less susceptible to fungal and microbial infection, making them suitable for use in low moisture content starch applications (Nuwamaya *et al*., 2011).

The highest fat content of starch was found in sweet potato, pot-x-igariam (0.22 %), and the lowest in cassava sample um37 (0.12 %). There were significant differences in fat content among the starches studied ($p \leq 0.05$). The samples' fat content was generally low. Solubility increases when fat content is low. Kim and Wiesenborn (1996) also noticed this and attributed it to the low fat content. Protein content was highest in cassava starch sample um37 (30572 = 1.225%) and lowest in cassava starch sample um37 (30572 = 1.225 %) (0.169%). There was a statistically significant difference (p0.05) between the starch samples. In terms of protein content, 419, um37, and potato starch samples all had the same mean. The presence of biomolecules such as protein and fat concentrations in starches explains why they are difficult to extract and produce in completely pure form. The ash content of the starches ranged from 0.05 to 0.15 % (um37) (Nxs003). The ash content of cocoyam sample Nxs003 and cassava sample 419 (0.14 %) was comparable. Oladunmoye *et al.* (2014) reported an ash content of 0.1 % for cassava starch (2014). Cassava sample 419 (0.11 %) had the lowest crude fiber content of the starches and cocoyam sample Nxs had the highest (0.15 %).There was no significant difference ($p \geq 0.05$).

Physico-chemical properties of starch from cassava (419, UM37, 30572), sweet potato (*X-IGBARIAM*) and cocoyam (NXS003, *EDEUHIE*) roots

Amylose, Amylopetin, Reducing sugar, and starch yield results are shown in (Table 2). The content of amylose ranged from 15.04 % (Um37) to 18.755 % (pot). The Amylose content of starches determines the majority of its uses and, in most cases, the properties of starch. The obtained results revealed a significant variation in the amylose content for the various botanicals studied. Kim and Wiesenborn (1996) found comparable amylose levels in mainechip potato starch (22.7%) and commercial food grade potato starch (20.0%) from Avebe Company Veendam, Netherlands. Amylose content is a critical factor in almost all starch properties. Low amylose contents cause an increase in the relative crystallinity of starch as a result of reduced amorphous regions in the starch granule (Tukomane *et al*., 2007). The amylose component of the starch influences swelling and hot-paste viscosity (Shimelis *et al*., 2006). Because the amylose content of starch influences its retrogradation (Klucinec and Thompson, 2002), the correlation between starch and amylose suggests the retrogradation pattern of starch in different cultivars. Lower amylose content is an excellent choice for improved digestibility (Riley *et al*., 2006). The amylopection content ranged from 81.24 to 84.9 % (Sweet Potato) (Um37).

Table 1: Proximate composition of starch from cassava (419, um37, 30572), sweet potato (*x-igariam*) and cocoyam (nxs003, *edeuhie*) roots.

Sample	Moisture (%)	Fat (%)	Crude protein (%)	Ash (%)
419	13.2^{a}	0.14^{cd}	0.175^{b}	0.14^{ab}
um37	12.4^{ab}	0.12^{d}	0.169^{b}	0.05^{c}
30572	11.6^{bc}	0.18^{abc}	1.225^{a}	0.11^{ab}
pot	11.4^{c}	0.22^{a}	1.173^{b}	0.10^{b}
Nxs	10.2^{d}	0.17^{bc}	1.05^{a}	0.15^{a}
ede	12.4^{ab}	0.20^{ab}	0.35^{b}	0.10^{b}
LSD	0.05	0.056	0.156	1.00

Means with different superscript within the same column are significantly different (p≤0.05). There is no significant difference among superscript with (a, ab, abc),(b, bc, abc) and (c, bc, abc) 419, um37and 30572 = cassava varieties, ede (*edeuhie*) and Nxs (*xanthosoma*) = cocoyam varieties, pot *(x-igbariam*) = white skinned sweet potato variety.

Table 2: Physicochemical properties of starch from from cassava (419, um37, 30572), sweet potato (*x-igbariam*) and cocoyam (nxs003, *edeuhie*).

Samples	Amylose (%)	Amylopectin (%)	Reducing sugar (mg/100g)	Starch yield (%)
419	16.05^{c}	83.95^{c}	68.10^{b}	59.4^{b}
um37	15.04^{e}	84.96^{a}	41.41^{f}	62.2^{a}
30572	15.34^{d}	84.66^{b}	56.82^{d}	58.7^{b}
Pot	18.76^{a}	81.24^{e}	72.23^{a}	57.4^{c}
Nxs	16.10^{b}	83.30^{d}	44.41^{e}	55.9^{d}
Ede	16.16^{b}	83.84^{c}	57.57^{c}	59.4^{b}
LSD	1.00	1.00	1.00	1.00

Means with different superscript within the same column are significantly different (p≤0.05). 419, um37and 30572 are cassava starch, ede *(edeuhie*) and Nxs (*xanthosoma*) are cocoyam starch, pot (*x-igbariam*) is white skinned sweet potato.

Cassava starches had higher amylopectin content than cocoyam (edeuhie and NXS003) and sweet potato. Amylopectin levels were higher in cocoyam samples than in sweet potato starch. A high amylopectin concentration indicates a high quality native starch (Kwadwo, 2018). When gelatinized, cassava starch has the ability to form a more viscous soft gel rather than a rigid paste. Because of its low amylose content, cassava starch is a better option for use in frozen foods. Sugar reduction was greatest in sweet potato (72.23mg/100g) and lowest in Um 37 cassava (44.41 mg/100g). There were significant differences between the samples (P 0.05). The starch yield ranged from 55.9 % (NX5003) to 62.2 % (Table 2). (Um37). In terms of % age starch yield, there were significant differences (P 0.05) between the samples. According to the starch yield results, cassava, sweet potato, and cocoyam contained an adequate amount of starch and were within the range of starch contents reported for roots and tuber crops.

pH and total titratable acid (TTA)

The pH of the samples is depicted in Figure 2. It was highest in the sweet potato starch sample (7.45) and lowest in the cocoyam starch sample Nxs (6.25). The pH of the starch samples ranged from 6.25-7.45, indicating that they were low acid to low alkaline. Because it influences the taste of food, pH is an important indicator of eating quality (Oduro *et al*., 2003). Because flour starch with a pH of 4 or less will have a characteristic sour aroma and taste due to fermentation, which is undesirable in starch production, pH is a good quality indicator for starch. The total titratable acidity (TTA) result in (Figure 3) recorded the highest TTA in the sweet potato sample (pot = 0.11) and the lowest in the cocoyam

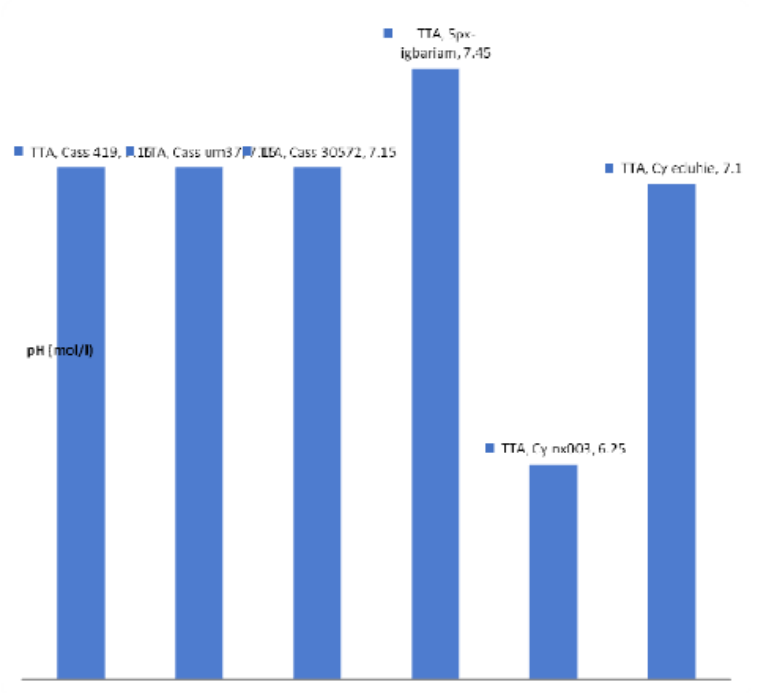
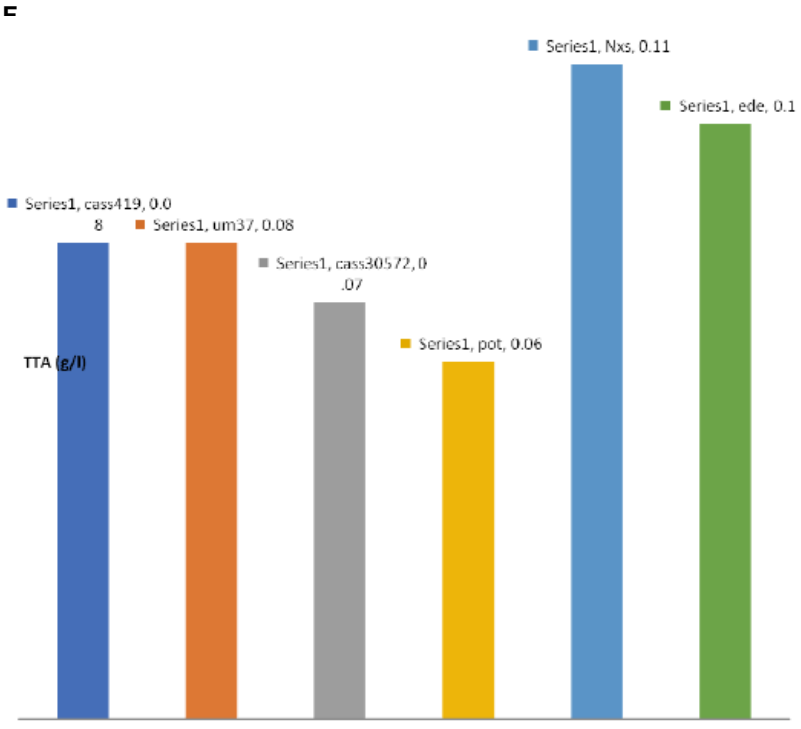


Figure 2: pH of starch from cassava (cass 419, cass um37, cass 30572), sweet potato (spx-*igbariam*) and cocoyam (cynxs003, *cyedeuhie*) roots.



acidity (TTA) of starch from s from cassava (cass 419, cass um37, cass 30572), sweet potato (pot) and cocoyam (nxs003, *edeuhie*) roots.

sample Ede (0.06), despite the fact that they were all within an acceptable range for starch products.

Conclusion

Amylose content ranged from 15.04% (Um37) to 18.755 % (pot), and amylopection content ranged from 81.24% (Sweet Potato) to 84.9% (pot) (Um37) Sugar reduction was greatest in sweet potato (72.23mg/100g) and lowest in Um 37 (44.41 mg/100g). The pH of the starch samples ranged from 6.25-7.45, indicating low acidity and higher acidity. TTA was highest in the sweet potato sample (pot = 0.11) and lowest in the cocoyam sample Ede (0.06), despite the fact that they were all within the acceptable range for starch products. The moisture content of the starches varied depending on the botanical source, with cassava starch 419 having the highest (13.2%) and cocoyam sample Nxs003 having the lowest (10.2%). The highest fat content of starch was found in sweet potato, pot-x-igariam (0.22%), and the lowest in cassava sample um37 (0.12%). Protein content was highest in cassava starch sample 30572 (1.225%) and lowest in cassava starch sample um37 (0.169%). The ash content of the starches ranged from 0.05 to 0.15 % (um37) (Nxs003). The ash content of cocoyam sample Nxs003 and cassava sample 419 (0.14%) was comparable. Cassava sample 419 (0.11 %) had the lowest crude fiber content of the starches and cocoyam sample Nxs had the highest (0.15 %). The significant difference in the chemical and nutritional properties of the various starch sources suggests that the starches have different utilization properties for industrial and food use.

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