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Raw-Material Potentials of Nigerian Wild Polynesian Arrowroot (*Tacca leontopetaloides*) Tubers and Starch

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Abstract: Wild Polynesian arrowroot (*Tacca leontopetaloides*) tubers collected in Nigeria were assessed for their tuber and starch characteristics. The fresh and stored (4 months) tubers were evaluated for their relevant physico-chemical properties, while the starch samples (extracted from them) also had their functional properties and physio-chemical properties determined. The results showed that the bitter brown skinned tuber had 28.25-29.00% dry matter content, 25.00-27.25% starch content, 1.67 g mL^{-1} density, 40-43 mg/100 g ascorbic acid and 3.15-3.58% crude flavonoid extract. The proximate composition of the tuber flesh was 1.10-1.50% protein, 2.70-2.73% ash, 0.28-0.68% fibre, 0.08-0.10% fat and 95.02-95.42 total carbohydrate on dry matter basis. The white coloured starch samples had 10.00% moisture content, 0.71-0.77 g mL^{-1} packed bulk density, 6.55-6.75g g^{-1} water absorption capacity, 6.90-7.30 oil absorption capacity, while the paste clarity (percent transmittance) generally tended to increase with storage. The potential usefulness of the starch in aqueous and hydrophobic food and drug systems was observed, while the medicinal value of the tuber flavonoid content needs further investigation.

Key words: Polynesian arrowroot, tuber characteristics, starch quality, food, medicinal value, Nigeria

INTRODUCTION

Polynesian arrowroot (*Tacca leontopetaloides* (L.) Kuntze Syn. *T. pinnatifida* Forst., *T. invducrata* Schum and Thonn) is a wild plant in Nigeria known to have been domesticated in the Pacific island nations (Purseglove, 1972; Kay, 1987). The underground tubers are relatively hard and potato-like. The tuber starch of Polynesian arrowroot serves as an important food source for many Pacific Island cultures, especially amongst the inhabitants of Low Islands (Kay, 1987). The starch is also, additionally used to stiffen fabrics in some of the islands. The bitter raw tubers on the other hand are generally used to treat stomach ailments (mainly diarrhea and dysentery) in many Polynesian islands (Kay, 1987; Brand-Miller *et al*., 1993).

The observed luxurious growth of wild Polynesian arrowroot in Nigerian bushes during the humid seasons has led to numerous enquires to our research institute (by food processors and other agro-allied industrialists) on the possible beneficial uses of these largely ignored underground tubers. This is more so as, recent studies have demonstrated a close taxonomic family relationship between the local cherished food yams (*Dioscorea* species) and the Taccaceae (now Tacca) genera that include Polynesian arrowroot (Caddick *et al*., 2002).

The dearth of scientific information on the tuber and starch characteristics of wild Polynesian arrowroot in Nigeria for relevant end users therefore, led to this investigative study. It is hoped that other African countries that have wild Polynesian arrowroot will also benefit from the result of the study, as some of them occasionally used it as a famine food for resource poor farmers (Kay, 1987).

MATERIALS AND METHODS

Source of experimental tubers: Freshly harvested and stored (4 months) wild Polynesian arrowroot tubers used for the experimentation were obtained from Sugar Beet and Other Root Crops Programme of National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria in January, 2009. These tuberous materials were originally collected randomly in the wild at scattered bushes in the North Central Agro-ecological zone of Nigeria.

Tuber characterization and proximate composition: Weighed tubers of the randomly selected tubers (freshly harvested and stored) were used to determine the primary physical (mean density, peel loss), sensory (flesh colour, skin colour, taste) and chemical/biochemical (moisture, starch, ascorbic acid, crude flavanoid contents) attributes (Onwuka, 2005) in quadruplicates.

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Volumes obtained by water displacement were used to calculate the mean tuber density (mass/volume), while weights of tubers and manually removed peels (with kitchen knife) were used to determine the percentage peel loss (100× wt of peels wt^{-1} of unpeeled tubers). Standard gravimetric methods (Bainbridge *et al*., 1996; Onwuka, 2005) were used to determine the mentioned chemical/biochemical contents of the raw-tubers and the proximate composition of the dehydrated tuber flesh samples (also in quadruplicates).

Preparation of the polynesian arrowroot starch samples: Starch samples from the experimental tubers were prepared by slight modification of the method for cassava (*Manihot esculenta*) starch preparation (Ukpabi, 2008). The unit and sub unit operations are as shown in Fig. 1 included: manual peeling, washing (in clean water), homogenization (electric blender), filtering (muslin cloth), sedimentation, decanting (of watery supernatant), mechanical drying to brittleness (Oven BS, Gallenkamp, England) and milling to obtain powdered starch.

Starch characterization: Standard methods (Onwuka, 2005) were also used to determine the simple functional properties (water absorption capacity, oil absorption, swelling index, emulsion capacity, packed bulk density) of the starch samples with 15 replicates. Swelling index was determined by soaking measured volume of starch in distilled water (inside a measuring cylinder) at ambient room temperature (26-29°C) for 4 h.

$$\text{Swelling Index (SI)} = \frac{\text{Final volume of soaked starch}}{\text{Initial volume of starch}}$$

Determination of the packed bulk density involved the compacting of weighed starch sample in glass measuring cylinder by slight tapping of the bench top holding the measuring cylinder. As in the tuber characterization, colour and taste were determined sensorily, while fibre and moisture contents were determined gravimetrically (Onwuka, 2005). The paste clarity (percent transmittance of dilute starch suspensions) was determined with UV/visible spectrophotometer (Jenway 6405, England) at only ambient room temperature (26-29°C) using the method of Bhandanri and Singhal (2002).

Statistical analysis: The statistical analyses were done, with the Statistical Analysis System (SAS) software version 8 (TS MO) licensed to International Institute of tropical Agriculture, Ibadan, Nigeria (site 0022206002).

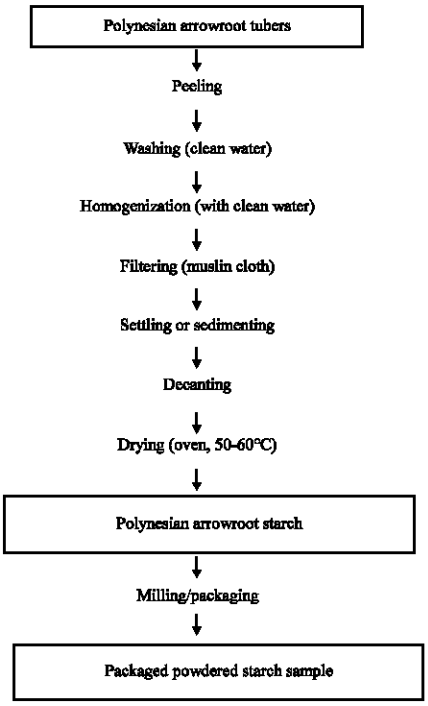

Fig. 1: Flow chart for the starch production

RESULTS AND DISCUSSION

The results of the tuber characteristics of the experimental wild Polynesian arrowroot samples (with a weight range of 42-2664 g) are shown in Table 1. It could easily be deduced that the tubers are highly starchy and prone to enzymatic browning especially after prolonged storage. Phenolics and their oxidases are known to cause oxidative browning in cut surfaces of tuberous crops (Okaka and Okaka, 2001). The flesh of the experimental tubers was found to have appreciable quantity of vitamin C as generally found in Nigerian indigenous edible tuber crops (Rehm and Espig, 1991; Okaka and Okaka, 2001). Onimowo and Akubor (2005) showed that ascorbic acid (vitamin C) reacts with reducing sugar to cause non enzymatic browning. The level of the tuber's crude flavonoid extract that has bitter flavoniod glycoside principle (taccalin) is also appreciable. The phenolic taccalin (3,5,7,4^1-tetrahydroxy flavylium 3-xyloside) contribution to food browning or colouring would probably be masked by its recorded medicinal value in stomach ailments (Kay, 1987). In addition to the general body antioxidant effects of the flavanoids (Lotito and Frei, 2006), the water soluble flavylium aglycone of taccalin, like those of related flavanoid subgroups and their soluble salts, has been shown to

Table 1: Tuber characteristics of the freshly harvested and stored wild Polynesian arrowroot

Characteristics	Fresh	Stored
Dry matter (%)	29.50±0.7	28.25±0.4
Starch content (%)	27.25±1.2	25.00±2.3
Mean density (g mL^{-1})	1.67±0.1	1.67±0.3
Flesh colour (after cutting)	Cream	Cream with rapid browning
Skin colour	Dark brown	Dark brown
Peel loss (%)	13.81±0.4	16.11 + 0.2
Vit. C (mg/100 g)	40.01±0.1	43.20±0.1
Crude flavonoid extract (%)	3.15±0.2	3.58±0.1
Taste	Bitter	Bitter

Table 2: Proximate composition of the freshly harvested and stored wild Polynesian arrowroot tubers on dry mater bases

Proximate composition	Fresh	Stored
Crude protein (%)	1.10±0.1	1.50±0.2
Ash (%)	2.70±0.1	1.73±0.2
Crude fibre (%)	0.68±0.3	0.28±0.0
Fat (%)	0.10±0.0	0.08±0.3
Carbohydrate (%)	95.42±0.4	96.42±0.1
Energy (Cal/100 g)	388.70±1.8	392.50±1.9

Table 3: Functional properties of the Polynesian arrowroot starch samples

Functional properties	Fresh	Stored
WAC*	6.75a	6.55a
OAC**	6.90b	7.30a
Emulsion capacity (g g^{-1})	3.70b	3.85a
Swelling index (g mL^{-1})	1.31a	1.30a
Bulk density (packed) (g mL^{-1})	0.77a	0.71a

*WAC = Water Absorption Capacity, **OAC = Oil Absorption Capacity, Values in a row with the same letter are not significantly different (p = 0.05)

Table 4: Selected physicochemical properties of polynesian arrowroot starch samples

Physicochemical properties	Fresh	Stored
Colour	White	White
Fibre (%)	0.00	0.00
Moisture (%)	10.00	10.00
Paste clarity (% T in H_20) in concentrations		
0.05	11.8±3.8	18.5±6.4
0.10	3.3±0.9	9.0±4.1
0.20	-2.3±0.07	-0.6±1.7
0.30	-9.2±0.4	-3.2±2.6
0.40	-5.5±0.5	-5.2±0.0

inhibit the development of intestinal fluids that result in diarrhea (Schuier *et al*., 2005). Therefore, further research is necessary to know how the bitter flavanoid extract could be used as a nutriceutical or in pharmaceutics.

The proximate composition of the dehydrated experimental tubers (Table 2) showed relatively very low protein, fat and fibre contents with an inherent high calorific value (in both the fresh and stored samples). The earlier data obtained in Africa (probably in the Congo Basin) for the proximate composition of wild Polynesian arrowroot dehydrated tubers were 89.4% carbohydrate, 8.8% fibre, 0.2% either extract and 1.5% protein (Kay, 1987). Therefore, the elimination of the bitter principle in the wild Polynesian arrowroot tubers will provide Nigerians and other Africans an alternative energy rich (>1.5 MJ/100 g) dehydrated processed food and feed stuff. These imply that the removal of the bitter principle in the fresh and fairly stored tuber (with relevant biochemical and chemical techniques) would give a carbohydrate or energy rich food material for human and animal consumption.

The taste of the experimental starch samples was found to be bland and the results of their functional properties (Table 3) indicate the potential usefulness of arrowroot starch obtained from the wild variety in Nigeria in the preparation of aqueous and hydrophobic food and or drug systems. However, the emulsion capacity of the starch samples was observed to have limited value (Table 3) for food systems that require high emulsion capacity. The bulk density and swelling index data will, respectively be helpful to the marketers and end users of the packaged starch.

The experimental starch samples also have the white colour and zero fibre content (Table 4) required in the international market for the arrowroot starch (Brand Mille *et al*., 1993). The values for the starch paste clarity (% light transmittance) for the different aqueous suspensions at varying concentrations (Table 4) showed that tuber storage could affect the inherent results, probably due to starch autohydolysis or breakdown (to glucose) during tuber storage as Bello-Perez and Paredez-Lopez (2006) found that increased glucose concentration around starch molecules tend to increase paste clarity.

The full potential of the local wild arrowroot variety as an important source of commercial starch needs to be further investigated along with that of the medicinal value of the tubers. More comprehensive economic useful results from the investigations may even encourage the domestication or cultivation of this tropical plant in Nigeria and some other African countries.

CONCLUSION

The potentials exist for the utilization of the tubers of Nigerian wild Polynesian arrowroot tubers in the local and regional food and feed industries (as an energy material) after the elimination of the taccalin based bitter flavanoid content. Medicinal or nutriceutical use of extracted flavanoid content is also, possible after further multi disciplinary research. The extracted white bland starch could also be used in relevant food and related industries as a thickening or binding agent.

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