

Physicochemical Properties of Processed Aerial Yam (*Dioscorea bulbifera*) and Sensory Properties of Paste (*Amala*) Prepared with Cassava Flour

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ABSTRACT

Aerial yam is a member of the Dioscoreaceae family which consist several varieties found in South Asia and Africa. The tubers are under-utilized and not commercially grown; but are cultivated and consumed among rural dwellers in parts of Western Nigeria. The tubers were washed, sorted, peeled, sliced and blanched in hot water at 80°C for 10min. The blanched yam slices were divided into four portions. Two portions were fermented for 48hr and sun (BFSUD) and solar (BFSOD) dried. The other two blanched portions were also sun (BSUD) and solar (BSOD) dried respectively. The dried slices were milled, sieved and used for proximate, functional and phytochemical analysis. Proximate composition of aerial yam flour was: moisture content (7.66-10.60%), total ash (0.05-1.76%), crude protein (4.42-5.07%), crude fibre (0.56-0.69%), crude fat (3.42-3.82%), and carbohydrate (79.28-82.37%). The phytochemical constituent included alkaloid, steroids, saponin and flavonoid. The bulk density, water absorption capacity and dispersibility were within the range of 0.52-0.54g/ml, 56.50-66.00g/g and 4.47-5.75% respectively. The sample, BFSUD had the highest crude protein, dispersibility and water absorption capacity was selected and mixed with cassava flour for amala on which sensory evaluation was conducted. Five aerial yam flour (AY) treatments were formulated and coded as follow: AY₁₀₀, AY₈₀CS₂₀, AY₆₀CS₄₀, AY₄₀CS₆₀, and AY₂₀CS₈₀. Cassava flour (CS₁₀₀) was used as control treatment. The overall acceptability of flour paste (amala) ranged from 5.45 (Sample AY₈₀CS₂₀) to 7.25 (sample AY₁₀₀). The study revealed treatment AY₆₀CS₄₀ and AY₈₀CS₂₀ possessed the overall acceptability, mean score above 7.0 (like slightly). Therefore 60-80% incorporation of aerial yam flour with cassava is recommended based on desirable sensory characteristics. Aerial yam flour can be used for food preparation and commercial purpose which may in turn increase the utilization.

Keywords: Aerial yam, Amala, Cassava, Composite flour

INTRODUCTION

Roots and tubers can basically provide energy from carbohydrate in human diet as minerals and some essential vitamins in human diets (Hahn, 1995). High moisture content of these crops result in short storage life at ambient condition. Root crops have been regarded as food for the poor and less popular in the international trade due to lack of appreciation (FAO, 1990).

Yams are the edible tubers of various species of the genus *Dioscorea* and considered as staple

foods of many tropical countries including Côte d'Ivoire, Ghana, Togo, Burkina Faso and Nigeria (Kouakou *et al.*, 2010; Amanze *et al.*, 2011). Yam is cultivated mainly in three areas of the world; namely West Africa, parts East-Central and Southern Africa (FAO, 1999) and produce about 95% of the world yam production, followed by South-East Asia including China, Japan and Oceania. The third area includes the Caribbean, Mexico, and parts of Central America (FAO, 1999). Yams serve

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as a major contributor to food security in West Africa (Zannou, 2006), but out of the over 600 known yam species, only seven are mostly consumed (Jayakody *et al.*, 2007). These include *Dioscorea rotundata* Poir (White yam), *Dioscorea cayenensis* (Yellow yam), *Dioscorea alata* (Water yam), *Dioscorea bulbifera* (Aerial yam), *Dioscorea esculenta*, *Dioscorea praehensalis* (Bush yam) and *Dioscorea dumetorum* (Bitter yam). *D. rotundata* is the most important species grown and consumed in Ghana, in terms of area planted and quantity produced (Otoo and Asiedu, 2008). In Nigeria, yam is one of the major crops in the farming systems and commercially produces different varieties of *D. rotundata*. *D. cayenensis*, *D. bulbifera*, *D. dumetorum* and *D. esculenta* are cultivated in lesser quantity for domestic use (Tetteh and Saakwaa, 1994).

The edible species of *D. bulbifera* are grown extensively in West Africa, Caribbean Islands, South-East Asia, South Pacific and West Indies. The wild forms occur in both Africa and Asia. *D. bulbifera* is used as food and it provides substantial amount of calories and minerals such as iron, calcium and phosphorous (Tindall, 1983; Abara *et al.*, 2000). *Dioscorea bulbifera* tuber is a rich source of starch that forms an important dietary supplement (Deb, 2002). Apart from starch, the root tubers of *Dioscorea* species contain protein, fat, fiber and some minerals such as Potassium, Sodium, Phosphorus, Calcium, Magnesium, Copper, Iron, Manganese, Zinc and Sulphur (Deb, 2002). "Diosgenin" is a pharmacologically active component of *Dioscorea* obtained from root and rhizomes which is one of the most costly and important steroidal drug used worldwide (Sharma, 2004). Dietary PEs (plant estrogens) of *Dioscorea* can provide a wide range of health benefits including protection against development of cancer, osteoporosis, cardiovascular disease, nephritis, asthma, diabetes, and used in the preparation of contraceptives and in the treatment of various genetic disorders (Ayoola *et al.*, 2008). Aerial yam also known as air potato, Adun, Odun,

Kanduin in some regions of Nigeria though predominantly in the Western and Eastern regions is grown for its bulbils and eaten during the famine season. Even though it possesses a distinctive flavour and comparable in nutritional content to the most preferred yam species, it does not possess the same appeal compared to *D. alata* L. and *D. rotundata* Poir. The yam is unpopular; less studied, and received minimal interest and attention by food processor in Nigeria. The high rate of post-harvest losses of the crop and inadequate method of preservation probably resulted in its under exploitation as foodstuff and industrial uses.

Cassava (*Manihot esculenta* crantz) is one of the few most important root crops known and used in many countries of Africa, Latin America and some Asian countries. Though it has origin at South America, cassava has become an indigenous crop in the tropics having been widely grown and used. Cassava is a staple food for over 500 million people in the developing world (Cock, 1985). It has played vital roles in the diets of many African countries as a major source of low cost carbohydrate (O'Hair, 1990). The emphasis on protein deficiency of cassava is due to ignorance of food habits in regions where cassava is the people's main food (Ihekoronye and Ngoddy, 1985). This research is designed to determine the physicochemical properties of differently processed and dried aerial "yam" (*D. bulbifera*) and to assess the sensory properties of *Amala* (paste) produced from the composite flour mixture with cassava flour.

MATERIALS AND METHODS

Source of sample

D. bulbifera was purchased from local market in Aduratedo-Ape, Kabba, Bunu LGA, Kogi State, Nigeria, while Cassava flour (*Lafun*) was sourced from Oja-Oba market in Ilorin, Kwara State, Nigeria.

Processing of *Dioscorea bulbifera* tubers for flour production

The tubers of *D. bulbifera* were washed with clean water to remove adhering soil and other undesirable materials. The yam samples were sorted and hand-peeled using kitchen knives and then sliced into sizes of 2 to 3cm in thickness. The sliced yam was soaked in water at 50°C while, peeling to avoid enzymatic browning and also to remove the bitter compound from the sliced samples. The slices were blanched with hot water at 80°C for 10min. The blanched yam slices were then divided into four portions. Two portions of the treatment samples were returned to the steep water and allowed to undergo natural fermentation for 48hours before it was drained.

A portion of the blanched sample and the blanched-fermented sample were sun-dried to constant weight within five days, while the other portion were dried for 5days in a glass solar dryer fabricated in the Department of Physics, University of Ilorin, Nigeria. Temperature

(55°C) and relative humidity (16.4%) were controlled in the solar dryer.

The dried yam slices were milled using locally fabricated hammer mill and screened (1mm sieve) to aerial yam flour and then stored in an air tight container prior to analysis. The differently processed and dried samples of *D. bulbifera* are presented in Figure 01.

Proximate analysis of processed aerial yam flour

The proximate composition of the aerial yam flour samples were analyzed using the standard methods of AOAC (2005). The samples were analyzed for moisture, total ash, crude fibre, crude fat, crude protein and carbohydrate (by difference).

Phytochemical screening of aerial yam flour

Qualitative phytochemical screening was carried out on the aerial yam flour samples using the standard procedures of Safowora (1993) and Evans (1996).



BFSUD: Blanched fermented sun-dried
BFSOD: Blanched fermented solar-dried
BSUD: Blanched sun-dried
BSOD: Blanched solar-dried

Figure 01: Processed and dried samples of aerial yam (*D. bulbifera*)

Water Absorption Capacity of the Aerial yam flour

Water absorption capacity of the flour samples were determined by difference (Abbey and Ibeh, 2000). Two grams of the flour sample was weighed into centrifuge tube, 20ml of distilled water was added, the tube containing the sample was carefully shaken by vortex and allowed to stand at room temperature (25°C) for 30 min., it was centrifuge for 30 min. at 200 rpm, excess water was decanted by inverting the tube, the weight of the water was determined by difference as follow:

$$\text{Water absorption capacity (\%)} = (W_1 - W_2) / W_s \times 100$$

Where:

W_1 = Weight of residue in tube after centrifuge

W_2 = Weight of empty tube before centrifuge

W_s = Weight of sample used

Determination of Bulk Density of the flour

The bulk density of the aerial yam flour samples was determined according to the method of Giami, *et al.* (1992). Five grams of the sample was weighed into 50ml graduated measuring cylinder. The sample was gently packed by tapping the cylinder on the bench top 10 times from height of 5cm. The volume of the sample was recorded and bulk density calculated.

$$\text{Bulk density (g/ml)} = (\text{Weight of sample used} / \text{Volume of sample after tapping})$$

Assessment of dispersibility of aerial yam flour

The method described by Kulkarni *et al.* (1991) was used to measure the dispersibility. Ten grams sample of flour was weighed into 100ml capacity measuring cylinder, and water added

up to 100ml mark of the measuring cylinder. The set up was stirred vigorously and allowed to settle for 3hr. The volume of settled particles was recorded and subtracted from 100. The difference was then reported as percentage dispersibility (Kulkarni *et al.*, 1991).

$$\text{Dispersibility (\%)} = 100 - \text{Volume of settled particle}$$

Sensory evaluation of Amala produced from composite flours of aerial yam and cassava

The samples of *D. bulbifera* and cassava (*Lafun*) flours are shown in Figure 02. After analysis of the flour obtained from the four differently processed and dried aerial yam samples namely: BFSUD, BFSOD, BSOD and BSUD, The sample BFSUD, which had the highest crude protein and functional attributes was selected for the formulation of the aerial yam-cassava flour mixtures. The aerial yam and cassava flours were mixed at different ration as follow: 100:0 (AY_{100}), 80:20 ($AY_{80}CS_{20}$), 60:40 ($AY_{60}CS_{40}$), 40:60 ($AY_{40}CS_{60}$), 20:80 ($AY_{20}CS_{80}$) and 0:100 (CS_{100} ; used as control). The six flour treatment samples were used to prepare flour paste called “Amala” in the Western part of Nigeria. Two hundred grams of each sample was weighed and continuously stirred with 150 ml of boiling water until properly cooked to produce a smooth paste (*Amala*). Sensory attributes (taste, colour, flavour, texture and overall acceptability) were tested using Hedonic scale (9 points) with 20 consumers on reconstituted hot paste of flour (*Amala*) were asked to evaluate the prepared hot aerial yam flour pastes (*Amala*) Ihekoronye and Ngoddy, (1985).

Statistical analysis

Data were subjected to analysis of variance using SPSS version 16.0, while means were separated using Duncan’s Multiple Range Test (Duncan, 1955).



Figure 02: Representative sample of aerial yam (AYF) and cassava (CSF) flours

RESULTS AND DISCUSSION

Effect of processing methods on proximate composition of aerial yam (D. bulbifera) flour

The proximate composition of aerial yam flour is given in Table 1. The moisture content on dry basis ranged from 7.66% (BSOD) to 10.60% (BFSOD). These values were close to the value (8.33%) reported by Abara *et al.*, (2003) in the dry tissue of *D. bulbifera*. There was a significant difference ($p < 0.05$) in the moisture content of the samples investigated (Table 01).

Total ash content of the sample ranged from 0.05% (BFSUD) to 1.76% (BFSOD). The result showed that there was significant difference ($p < 0.05$) between the studied samples. The total

ash of roots and tubers were reported as 0.6% to as high as 1.7% on wet basis (FAO, 1968; 1972; Watson, 1971; Eka, 1978; Abara *et al.*, 2003) and between 2.24% and 5.16% on dry basis (Oyenuga, 1968; Abara *et al.*, 2003) on yam tubers. Mineral content of foods varied but generally substantial amounts of mineral and trace elements is available. The mineral element depends on the chemical composition of soil, cultural practices, time of planting and the amount of water available to the tuber plant (Osagie, 1992). FAO (1968; 1972) reported the ash content of a sample of wet tissue of *D. bulbifera* as 1.0%. Abara *et al.* (2003) reported a value of 1.21% and Coursey (1983) reported a range of 1.1 to 1.5% of ash content.

Table 01: Proximate Composition of the aerial yam (*D. bulbifera*) flour

Sample Code	Proximate Composition					
	Moisture Content (%)	Total Ash (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	* Carbohydrate (%)
BFSUD	10.21±0.21 ^b	0.15±0.00 ^c	5.07±0.00 ^a	3.63±0.02 ^b	0.67±0.00 ^a	70.24±0.76 ^b
BFSOD	10.60±0.14 ^a	1.76±0.00 ^a	4.42±0.86 ^a	3.36±0.01 ^c	0.56±0.00 ^c	73.28±1.00 ^a
BSOD	7.66±0.19 ^d	0.73±0.02 ^b	4.70±1.39 ^a	3.82±0.03 ^a	0.69±0.00 ^a	75.39±1.22 ^a
BSUD	9.43±0.02 ^c	0.05±0.00 ^d	4.48±0.46 ^a	3.42±0.04 ^c	0.61±0.02 ^b	75.89±0.56 ^a

Means within column with different superscripts indicates significant difference ($P \leq 0.05$);

* Calculated by difference.

BFSUD = Blanched fermented sun-dried

BFSOD = Blanched fermented solar-dried

BSUD = Blanched sun-dried

BSOD = Blanched solar-dried

There was no significant difference ($p>0.05$) in protein content of the treated samples. The values were ranged from 4.42% (BFSOD) to 5.07% (BFSUD). Bell and Favier (1981) reported a fairly high range of crude protein from 6% - 9% on dry basis. Martin (1979), Barquar and Oke (1976) also reported higher protein levels of between 7.9 and 9.6% and 6.7-11.1% respectively for *D. bulbifera* on dry matter basis. Abara *et al.* (2003) also reported a figure of 5.75% in the dry tissue of *D. bulbifera*. Martin (1979) had reported that crude protein content of yam varied considerably among species and between cultivars and attributed the variations in the proximate principles to factors such as climatic condition, stage of maturity at harvest and length of storage time. These factors may be responsible for the amount of crude protein observed in the processed *D. bulbifera* tubers that was used for flour production in this study.

The crude fat in aerial yam flour ranged from 3.36-3.82%. Sample BSOD was significantly higher ($p>0.05$) when compared with other samples (Table 1). The crude fat of the treatment samples were close to values ranging from 2.24 to 5.16% as earlier reported by Oyenuga (1968) and Abara *et al.* (2003).

The crude fibre and total carbohydrate content of the samples ranged from 0.56% (BFSOD) to 0.69% (BSOD) and 70.24% (BFSUD) to 75.89% (BSUD) respectively. Crude fibre consists principally of cellulose and lignin together with small amounts of hemicellulose (Southgate, 1973). A similar value of crude fibre (0.72%) in *D. bulbifera* was reported by Coursey (1983) while higher values of 1.20% and 1.39% crude fibre were reported by FAO (1968; 1972) and Abara *et al.* (2003) respectively. The variation in recorded values in proximate composition of the treated *D. bulbifera* samples might be due to the differences in processing and drying

methods in flour production. Baah (2009) and Shanthakumari *et al.* (2008) reported similar high carbohydrate content for *D. bulbifera*. Abara *et al.* (2003) reported a value of 80.98% in the dry tissue of *D. bulbifera*.

Carbohydrate content constitutes the major dry matter component of all the dried *D. bulbifera* samples as same as in other yam varieties (Oyenuga, 1968; Ihekeronye and Ngoddy, 1985; Osagie, 1992).

Effect of processing methods on functional properties of aerial yam (D. bulbifera) flour

The functional properties of the aerial yam flour indicated water absorption capacity (WAC) ranging from 4.47g/g (Sample BSOD) to 5.75g/g (Sample BFSUD) (Table 02). The WAC of samples BFSUD and BFSOD were significantly higher ($p>0.05$) than other treatments. Hydrolytic effect of fermentation process may increase the WAC in aerial yam. Water absorption capacity of flour gives an idea of swelling capacity of starch granules during reconstitution (Adebowale *et al.*, 2005; Oladipo and Nwokocha, 2011).

Bulk density of flour is ranged from 0.52g/ml (BFSUD) to 0.54g/ml (BSOD). There was no significant difference ($p<0.05$) among treatments. Bulk density is generally affected by particle size, density of flour or flour blends and signified possibilities in packaging requirement, raw material handling and application in wet processing (Adebowale *et al.*, 2008a; Ajanaku *et al.*, 2012). The result of dispersibility which ranged from 56% (BFSUD) to 66% (BFSOD) of values indicated that flour could be easily reconstituted in water during preparation. Dispersibility is an index of the ease of reconstitution of flour into a fine consistency paste during stirring (Adebowale *et al.*, 2008a).

Table 02: Functional properties of the aerial yam (*D. bulbifera*) flour

Sample Code	Functional Property		
	Bulk Density (g/ml)	Dispersability (%)	WAC (%)
BFSUD	0.52±0.00 ^a	66.50±0.50 ^a	5.75±0.02 ^a
BFSOD	0.53±0.00 ^a	66.00±0.00 ^a	5.73±0.02 ^a
BSOD	0.54±0.00 ^a	60.50±0.70 ^b	4.47±0.02 ^c
BSUD	0.53±0.00 ^a	62.50±0.41 ^b	4.82±0.01 ^b

Means within column with different superscripts indicates significant difference ($P \leq 0.05$);

WAC = Water Absorption Capacity.

BFSUD = Blanched fermented sun-dried

BFSOD = Blanched fermented solar-dried

BSUD = Blanched sun-dried

BSOD = Blanched solar-dried

Phytochemical composition of aerial yam (*Dioscorea bulbifera*) flour

The Phytochemical constituent of aerial flour processed in different methods is given in Table 03. The result shows presence of flavanoids, alkaloids, saponin, and steroids. Diosgenin, a steroid saponin extracted from yam, is used as precursor for the synthesis of hormones and corticosteroids which improve fertility in males (Djerassi 1992). Saponins possess both beneficial effects (cholesterol-lowering) and deleterious properties (cytotoxic permeabilization of the intestine) and also exhibit structure dependent biological activities (Prohp and Onoagbe, 2012). The biological functions of flavonoids apart from its antioxidant properties include; protection against allergies, inflammation, free radicals, platelet aggregation, microbes, ulcers, hepatoxins, viruses and tumors (Trease and Evans, 2002). Alkaloid has been used for over two centuries as stimulant and is active against bacteria (Madziga *et al.*, 2010). Tannin was not detected in the processed aerial yam. This perhaps could probably justify the use of it flour as the anti-nutritional factor such as tannin which could be inhibitory to bioavailability of minerals and vitamins and affect digestibility and palatability of protein was not detected.

Sensory Evaluation of paste (Amala) produced from the composite flours of aerial yam (*D. bulbifera*) and cassava

The mean scores of sensory evaluation of “Amala” produced from composite flours of aerial yam and cassava is given in Table 04. Colour of the aerial yam-cassava composite flour is ranged from 6.75 (AY₂₀CS₈₀) to 7.45 (AY₄₀CS₆₀). There was no significant difference ($p > 0.05$) in ranking colour of *amala* among the six treatments. However, there was a significantly higher value ($p > 0.05$) than both sample AY₁₀₀ (6.15) and the control (5.75).

The taste and texture of sample AY₆₀CS₄₀ were the most acceptable by the panelists, while those of sample A₁₀₀C₀ were the least acceptable. Treatment AY₈₀CS₂₀ was scored the highest mean values for aroma (7.30) and overall acceptability (7.27). The overall acceptability for sample AY₆₀CS₄₀ and AY₈₀CS₂₀ were 7.27 and 7.23 respectively. Therefore 60-80% substitution of aerial yam into cassava flour is more acceptable by panelists and this range (60-80%) is recommended for use in flour formulations for desirable sensory characteristics.

Table 03: Phytochemical composition of the aerial yam (*D. bulbifera*) flour

Treatment Samples	Phytochemical composition				
	Alkaloid	Saponin	Steroid	Flavonoid	Tannin
Blanched fermented sun-dried	++	+	+	++	-
Blanched fermented solar-dried	+	+	+	++	-
Blanched solar-dried	+	+	+	++	-
Blanched sun-dried	+	+	+	++	-

Key: += Present in low concentration, ++ = Present in high concentration, - = Absent.

Table 04: Sensory evaluation of “Amala” prepared from a composite flour of aerial yam (*D. bulbifera*) and cassava

Sample Code	Sensory characteristics				
	Colour	Taste	Aroma	Texture	Overall Acceptability
AY ₁₀₀	6.15 ^b	4.70 ^b	5.40 ^b	5.65 ^b	5.45 ^b
AY ₈₀ CS ₂₀	7.40 ^a	6.50 ^a	7.30 ^a	6.85 ^a	7.27 ^a
AY ₆₀ CS ₄₀	7.25 ^a	6.95 ^a	7.05 ^a	7.15 ^a	7.23 ^a
AY ₄₀ CS ₆₀	7.45 ^a	6.15 ^a	7.05 ^a	6.85 ^{ab}	6.75 ^{ab}
AY ₂₀ CS ₈₀	6.75 ^a	5.80 ^{ab}	7.04 ^a	6.25 ^{ab}	6.70 ^{ab}
CS ₁₀₀ (Control)	5.75 ^c	6.15 ^{ab}	6.85 ^a	6.35 ^{ab}	6.30 ^{ab}

* Means within row with different superscripts indicates significant difference ($P \leq 0.05$)

AY₁₀₀ = 100% Aerial Yam and 0% Cassava

AY₈₀CS₂₀ = 80% Aerial Yam and 20% Cassava

AY₆₀CS₄₀ = 60% Aerial Yam and 40% Cassava

AY₄₀CS₆₀ = 40% Aerial Yam and 60% Cassava

AY₂₀CS₈₀ = 20% Aerial Yam and 80% Cassava

CS₁₀₀ (Control) = 0% Aerial Yam and 100% Cassava

CONCLUSION

The fermentation of aerial yam accompanied with sun and solar drying processes had positive influence on swelling capacity and ease of reconstitution of the composite flour into a fine consistency paste. Substitution of cassava flour with aerial yam flour (60 to 80%) had a more desirable and acceptable products. The

phytochemical composition of the aerial yam flour proved the evidence of health beneficial and nutrient bioavailability. Application of these findings in domestic and industrial purpose will provide a nutrient dense product; thus enhance the utilization of aerial yam.

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