Middle-East Journal of Scientific Research 14 (7): 947-951, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.14.7.2175

Proximate and Functional Properties of Five Local Varieties of Aerial Yam (*Dioscorea bulbifera*) in Ghana

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Abstract: The proximate and functional properties of varieties of aerial yam from five regions were investigated. Flour was produced from the aerial yam by oven drying, milling and sieving. The flours obtained were evaluated for their proximate and functional properties. The results indicated that the moisture content ranged from 61.55% and 71.09% on wet basis; ash content 2.8% to 5.57%; fat content 1.95% to 3.29%; protein content 5.32% to 7.27%; fibre 0.73% to 0.97% and carbohydrate from 11.86% to 25.78% The water binding capacity ranged from 280.54% to 323.13%; solubility from 20.28% to 24.35 %; swelling power from 6.37% to 8.81% and pH from 6.06 to 6.52.It was observed that, Volta region samples were significantly different from the other samples in terms of its nutritional content except for carbohydrate where Brong Ahafo recorded the highest. Volta region again was significantly different from the other samples in terms of its functional properties except for the Ph where it recorded the lowest value making it acidic. Generally, all the study samples were found to have good functional and nutritional properties making them all potentially good material for product development.

Key words: Firigima · Post-harvest loss · Characterize · Nutritional

INTRODUCTION

Roots and tubers are amongst the class of foods that basically provide energy in the human diet in the form of carbohydrate. They also provide some minerals, nutrients and the essential vitamins [1]. Root crops have been regarded as food for the poor and have not played a large role in international trade due to lack of appreciation of the large numbers of people who depend on these root crops [2]. Roots and tubers have high moisture content which results in short storage life under ambient condition.

Yams are generally amongst the root and tuber crops that are widely distributed throughout the tropics with a few of them in the temperate regions of the world [2, 3]. In Ghana, yam is one of the major crops in the Ghanaian food system with farmers commercially producing mostly twenty six varieties of *Dioscorea rotundata*. A few of the farmers cultivate *D. cayenensis, D. bulbifera, D. dumetorum* and *D. esculenta* for domestic use [4]. A lot of the yams are highly underexploited as food and for their industrial value. This is because little attention has been paid to root crops by policy-makers and researchers as their determinations have been concentrated on cash crops.

Dioscorea bulbifera is an aerial yam known also as potato yam, *Akam*, *Firigima* and *dundunbisa* throughout the various regions of Ghana [5]. It is found in several regions of Ghana though predominantly in the Northern and Upper regions. It is grown for its bulbis and eaten during the famine season. Even though it possess a distinctive flavour and comparable in nutritional content to the most preferred yams, it does not have the same appeal compared to *D. alata L.* and *D. rotundata Poir* [6] and so it is less studied and has high rate of post-harvest loss in Ghana [5].

Due to the fact that the *bulbifera* has received minimal interest and attention by food processors and the general populace of Ghana, this study seeks to characterise the *bulbifera* from the Volta, Ashanti,

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Central, Brong Ahafo and Northern regions of Ghana to fully uncover its potentials for food security, income generation for the farmers and nutritional enrichment in households. This study is also seeking to confirm the assertion that differences in nutritional and mineral contents of roots and tubers are as a result of varietal and environmental differences..

The samples have been analysed for their proximate and functional properties in the laboratory using AOAC methods.

MATERIALS AND METHODS

Source of Materials: Five varieties of the cultivated (edible) *D.bulbifera* were obtained from farmers in the Ashanti, Brong Ahafo, Central, Volta and Northern Regions of Ghana. The five samples, one from each region, were collected at the end of January 2012. The samples were sent to the Crops Research Institute of the Council for scientific and Industrial Research at Fumesua in the Ashanti region of Ghana for laboratory analysis.

Dioscorea Bulbifera **Flour Preparation:** The bulbis were washed, cleaned and rinsed very well with copious amounts of distilled water. *D. bulbifera* flour was prepared by peeling and slicing the bulbis into 1cm thick and washing them in distilled water to remove all grits and mucilaginous material as much as possible. The slices were then oven dried at 60°C for 72 hours to constant mass, milled with a locally manufactured hammer mill, sieved with a 0.25µm sieve and stored in air-tight polyethylene bags and labelled for further analysis (Fig. 1)

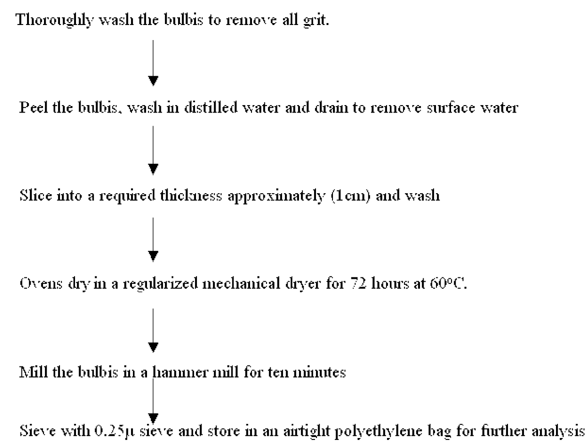

Fig. 1: Flow chart for the Dioscorea bulbifera yam flour preparation

Proximate Analysis: Proximate analysis of samples was determined according to AOAC [8, 9] the samples were analyzed for moisture, ash, protein, fat and carbohydrate (By difference).

Functional Properties Determination

Water Solubility Index (WSI) and Swelling Power (SP): Solubility and Swelling power determinations were carried out based on a modification of the method of [10]. One gram of yam flour/starch was dissolved with distilled water to a total volume of 40 ml using a weighed 50 ml graduated centrifuge tube. The suspension was stirred just sufficiently and uniformly avoiding excessive speed since it might cause fragmentation of the starch granules. The slurry in the tube was heated at 85°C in a thermostatically regulated temperature water bath for 30 minutes with constant gentle stirring. The tube was then removed, wiped dry on the outside and cooled to room temperature. It was then centrifuged at 2200 rpm for 15 minutes. The supernatant was decanted into a pre-weighed moisture can. The solubility was determined by evaporating the supernatant in a thermostatically controlled drying oven at 105°C and weighing the residue. The sedimented paste was weighed and swelling power was calculated as the weight of sedimented paste per gram of flour used.

$$\text{Sweelling power} = \frac{\text{Weight of sediment}}{\text{Sample weight-Weight of soluble}}$$

$$\%\text{Solubility} = \frac{\text{Weight of soluble}}{\text{Weight of sample}} \times 100$$

Determination of Water Binding Capacity: Water binding capacity of yam flour/starch was determined according to the method of [11] as modified by [12].

An aqueous suspension of yam flour/starch was made by dissolving 2.0 grams (dry weight) of flour in 40 ml of distilled water. The suspension was agitated for 1 hour on a Griffin flask shakes and centrifuged at 2200 rpm for 10 minutes. The free water (supernatant) was decanted from the wet flour, drained for 10 minutes and the wet flour/starch was then weighed. The water binding capacity was calculated by difference as follows

$$\%\text{Water binding capacity} = \frac{\text{Weight of bound water}}{\text{Weight of sample}} \times 100$$

Determination of pH: Ten grams of flour sample was weighed and dissolved in a beaker containing 25ml of distilled water to form slurry. It was allowed to stand for 10 min with constant stirring. The pH was then determined with a pH meter (Hanna Instruments, model HI 9017) in triplicate.

Statistical Analysis: Data was analysed using stat graphics (Centurion version) and Minitab (14^{th} version). Analysis of variance (ANOVA) was used to test for significant differences between the means. Duncan multiple range test was used to determine significant differences among the various samples.

RESULTS AND DISCUSSIONS

Proximate Analysis: The proximate composition of aerial yam flour was produced using oven drying method and presented in Table 1 in their percentage composition. The moisture content of every food sample reflects the quantity of solid matter in the sample. The rate of spoilage is closely related to the amount of moisture present. The higher the amount of moisture present, the higher the rate of spoilage.

The moisture content on fresh weight basis varied ($p<0.05$) between 61.55% and 71.09% and was found to be highest in the Volta samples whiles the Brong Ahafo samples recorded the lowest value. There was significant difference ($p\leq 0.05$) between the Volta and Brong Ahafo samples whiles the other samples were observed not to differ significantly. The values obtained in this study differed slightly from the value obtained by [13] which recorded 68.60% for light grey *D. bulbifera* and 64.13% for deep grey *D. bulbifera and* was lower *than* that reported by [14] (86.70%). The varieties with low moisture content may have a longer shelf life.

The protein content of all the samples were observed not to differ significantly with the exception of the Volta and Northern samples which were significantly different at $p\leq 0.05$. The protein content ranged between 5.32% and 7.27% with the Northern sample recording the lowest of 5.32% with the Volta sample obtaining the highest. The value obtained by the Volta sample was observed to be high compared to the values recorded by [16] There was however no significant difference $p\leq 0.05$ between the values of 5.38% and 5.30% obtained by [13] for *D. bulbifera* light grey and *D. bulbifera* deep grey respectively and the study samples.

Ash content of the different samples was significantly different ($p\leq 0.05$) and ranged between 2.87 and 5.57% with samples from Ashanti obtaining the lowest value and Volta with the highest value. This observation is in consonance with the values obtained in studies by [17 and 14] who recorded values of 3.37% - 4.27% and 3.31% respectively. The values observed in this study were in agreement with those reported in literature. [14, 17] which were found to range between 3.31 and 4.27% There was significant differences (p?0.05) between the studied samples with the exception of the samples from Ashanti and Brong Ahafo which recorded no differences between them. The variations observed could be due to varietal and environmental differences.

Table 1: Proximate compositions of flour samples (%)

Sample	Moisture	Protein	Crude Fat	Ash	Fibre	Carbohydrate
Central	68.38 ± 0.54^{a}	6.20 ± 0.07^{b}	1.95 ± 0.07^{d}	3.82 ± 0.05^{b}	0.95 ± 0.12^{ab}	18.70
Ashanti	66.38 ± 3.03^{b}	6.18 ± 0.16^{b}	3.29 ± 0.33^{a}	2.87 ± 0.06^{d}	0.73 ± 0.04^{d}	20.55
Brong	61.55 ± 1.11^{c}	5.86 ± 0.40^{c}	2.52 ± 0.63^{b}	3.32 ± 0.02^{d}	0.97 ± 0.01^{ab}	25.78
Northern	65.21 ± 1.39^{b}	5.32 ± 1.39^{d}	2.46 ± 0.08^{c}	3.65 ± 0.19^{c}	0.87 ± 0.01^{c}	22.49
Volta	71.09 ± 0.49^{a}	7.27 ± 0.49^{a}	3.28 ± 0.34^{a}	5.57 ± 0.14^{a}	0.93 ± 0.01^{ab}	11.86

Means with the same letters along the same column are not significantly different at p?0.05

Table 2: Functional properties of flour samples (%)

Sample	Swelling power	Solubility Index	Water binding capacity	pH
Central	8.81 ± 0.26^{a}	23.00 ± 0.21^{c}	311.87 ± 10.00^{a}	6.52^{a}
Ashanti	7.45 ± 0.22^{c}	23.05 ± 0.20^{b}	280.54 ± 2.73^{c}	6.36^{b}
Brong	7.59 ± 0.46^{bc}	20.28 ± 0.46^{c}	323.13 ± 7.12^{a}	6.02^{d}
Northern	6.37 ± 0.11^{d}	20.35 ± 0.28^{c}	296.20 ± 2.45^{b}	6.18^{c}
Volta	8.19 ± 0.21^{ab}	24.35 ± 0.40^{a}	311.27 ± 6.50^{a}	6.31^{b}

Means with the same letters along the same column are not significantly different at $p\leq 0.05$

The crude fat content of the Northern, Brong Ahafo and Central were observed to range between 61.55% and 68.38% and found to be lower than that reported by [16]. The values obtained for Volta and Ashanti are comparable to values obtained by [14, 16] and higher than values obtained by [13]. There were significant differences between the study samples which recorded a fat content range between 1.95% for Central and 3.28% for Volta samples.

Crude fibre content observed in this study was lower than that reported by other researchers [13, 14, 17]. This could be attributed to environmental differences. In the present study Brong Ahafo had the highest value of 0.97% while 0.73 was observed in the Ashanti samples. There were no significant differences between the studied samples. The carbohydrate content ranged between 18.04% and 30.80 % with Volta recording the lowest and Brong Ahafo the highest. These values were low compared to that reported by [14, 17] however comparable to that reported by [15]. The low carbohydrate content could be due to the high moisture content of the study samples.

Functional Properties: Water binding capacity (WBC) is used to determine if particular flour would be useful in the food system such as bakery items which require hydration to improve handling characteristics. High WBC is attributed to lose structure of starch polymers whiles low values indicates the compactness of the structure [21]. In the preparation of baked products, extruded snacks and mash, water binding capacity is an important parameter to be considered. high water binding capacity is essential for making mash whiles lower water binding is preferred for thinner gruels.

The water binding capacity of the study samples ranged between 280.54% and 323.20% with samples from Brong Ahafo obtaining the highest (WBC) and Ashanti the lowest. There were significant differences ($p \leq 0.05$) between the Volta, Brong Ahafo, Central samples which were not significantly different from that of North and Ashanti. The study samples were observed to have higher values than reported by [23, 24] for *rotundata* and cocoyam. Generally the water binding capacity observed for the studied samples were high, this may be due to lose structure of starch polymers [21]. The high WBC observed in this study is an important function that is essential in bakery products so as to improve handling characteristics and maintain freshness.

The swelling power (SP) ranged from 6.37 % in the Northern samples to 8.8% in the Central samples. The study samples obtained lower values than *rotundata* as reported by [23] and higher than cocoyam [24] this indicates that the study samples have good swelling power. There were significant differences between the Central and Northern samples. There was however no significant difference (p?0.05) recorded between Volta and Brong Ahafo samples and also between Brong Ahafo and Ashanti samples.

There were no significant differences ($p \leq 0.05$) between the Central, Brong Ahafo and Northern samples. However there was a significant difference ($p \leq 0.05$) between the Volta which recorded 24.35% and Ashanti which recorded 23.05%.

pH is used primarily to calculate approximately consumption quality and hidden attributes of foods. Acids contribute to the post-harvest quality of foods like fruits as taste is primarily a balance between sugar and acid content, therefore post-harvest assessment of acidity is necessary in evaluating the taste of flours.

The pH values ranged between 6.02% and 6.52% with Central recording the highest value and Brong Ahafo the lowest. This suggests the Brong Ahafo sample to be acidic than the rest of the samples studied.

CONCLUSIONS

In conclusion, the Volta region samples were significantly different from the other samples in terms of its nutritional content except for carbohydrate where Brong Ahafo recorded the highest. Volta region again was significantly different from the other samples in terms of its functional properties except for the pH where it recorded the lowest value making it acidic.

Generally, all the study samples were found to have good functional and nutritional properties making them all potentially good material for product development.

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