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Full Length Research

Proximate composition, functional and phytochemical properties of pre-heated aerial yam flour

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ABSTRACT: This study investigates proximate, functional properties and phytochemical composition of pre-treated aerial yam (*Discorea bulbifera*) flour. The aerial yam samples were divided into four equal parts and pre-treated differently (roasting, boiling, soaking), while the fourth part not treated served as control. Quality evaluation carried out includes the proximate, functional properties and phytochemical composition. The roasted-dried aerial yam flour had the highest values for crude fibre (1.82%) and carbohydrate (80.07%). The roasted-dried sample had the highest values in loose bulk density, water absorption capacity and swelling capacity (0.50 g/cm^3, 4.91 g/cm^3 and 1.34 g/cm^3, respectively), while the soaked-dried sample has the highest values for packed bulk density and emulsion stability which are 0.5647 g/cm^3 and 0.56 g/cm^3, respectively. The soaked sample showed highest value for peak and trough (148.13 and 142.92 RVU, respectively), while roasted sample showed highest values for breakdown, final viscosity and set back (7.21, 186.00 and 45.08 RVU, respectively). The soaked-dried sample having the highest values for carotenoid (4.71%), and lowest value for saponin (0.35%). The boiled-dried sample had lowest values for steroid (0.47 %), while roasted-dried sample had lowest value for alkaloid (0.12 %). This study showed that some inherent positive qualities (high phytochemical content with improved functional properties) of pre-treated aerial yam, with roasted being the most improved.

Key words: Aerial yam, functional, proximate, pre-treatment, phytochemical composition.

INTRODUCTION

Yams are starchy staples in the form of large tubers produced by annual and perennial vines grown in Africa, Americas, Caribbean, South Pacific and Asia. Yams (*Dioscorea spp*.) are important source of carbohydrate for many people of the Sub-Saharan region, especially in the yam zone of West Africa (Akissoe et al., 2003), and are the third most important tropical root crop after cassava and sweet potato (Onyeka et al., 2006).

Yams contribute more than 200 dietary calories per capita daily for more than 150 million people in West Africa and serve as an important source of income (Babalaye, 2003). There are 600 species (Amani et al., 2004) of yam, but only six (*Dioscorea rotundata, D. alata, D. alata, D. esculenta, D. Bulbifera* and *D. dumetorum*) are mostly grown as staple foods in tropical nations (Otegbayo et al., 2001).

The nutritional value of yam varies greatly between different species and amongst varieties of the same species: moisture: 50 to 78, carbohydrate: 15 to 40.61, protein: 0.087 to 8.7, crude fat: 0.3 to 2.7, crude fiber: 0.3 to 3.8, and ash: 0.5 to 2.6%. Moreover, the cooking and processing characteristics of yams, the eating and storage quality of yam-containing products could be greatly influenced by the starch properties (Wang et al., 2006). In many parts of West Africa including Nigeria, yam is processed into various food forms, which include pounded yam, boiled yam, roasted yam, grilled yam, yam balls, mashed yam, yam chips and flakes (Orkwor et al., 1997).

Phytonutrients are plant components, primarily secondary metabolites that have health promoting properties. The most predominant phytochemical characteristics of yam is dioscorine alkaloid and dioscorine saponin (Eka, 1998). Although dioscorine and diosegenin traditionally are considered toxic, such toxicity is removed by washing, boiling and cooking (Eka, 1998). The pigments found in aerial yams may be due to the presence of flavonoids and carotenoids (Okwu and Ndu 2006; Markson et al., 2010). The main physiological function of carotenoids is as precursor of vitamin A (Nocolle et al., 2003) It is already known that these toxic principles exhibit useful medicinal properties, so their presence in the yam species is a pointer to the medicinal value of yam flour samples (Afiukwa et al, 2015; Osagie 1992).

The processing of yams traditionally depends on the species; *D. rotundata* is more preferred for preparing boiled yam and pounded yam (Ajibola et al., 1988). Out of the six species commonly found in West Africa, *D. rotundata* is the most widely grown and generally considered to be the best in terms of food quality, thus commanding the highest market value (Markson et al., 2010; Otegbayo et al., 2001; Ike et al., 2006). There is a need to expand utilization of yam through industrial processing, while chemical and physical components of foods (yam) have been found to influence its end use.

Yam has been grossly researched in the following areas; quality attributes of yam flour (Adejumo et al., 2013), developing a yam flour processing system (Okafor, 2014), changes in the carbohydrate constituent of yam tubers during growth (Fetuga et al., 1973; IITA, 2011) ,Improving yam production technology (Babalaye, 2003), yam improvement for income and food security in west Africa (Ogbonna et al., 2012), comparative nutritional and phytochemical evaluation of the aerial and underground tubers of air potato (*Dioscorea bulbifera*) available in Abakaliki, Ebonyi State, Nigeria (Afiukwa et al., 2015, Ogbonna, 2001).

The poor knowledge of effects of pre-treatments (drying, roasting, boiling etc) on the components of yam, could have resulted into misuse, mishandling and wastage of these food product. The ignorance as to the nutrient composition of aerial yam has resulted into its underutilization. There is therefore the need to research into this rare used yam cultivar, aerial yam. Research into aerial yam, particularly effects of pre-treatment could uncover some inherent potentials or positive quality of the same, and also suggests the best pre-treatment method that could improve the quality and its acceptability as a product or complement to other foods. The objective of the study was to investigate the effect of pre-treatment on the Proximate composition, functional and phytochemical properties of pre-heated aerial yam (*Dioscorea bulbifera* flour.

MATERIALS AND METHOD

Material

The aerial yam (*D. bulbifera*) samples, the green cultivars were obtained from Wukari locality, (behind the Federal University) Wukari, Taraba state, Nigeria. Aerial yams (*D. bulbifera)* tubers were sorted by removal of defected tubers, and the yellow colour cultivar was selected and divided into four equal parts for the pre-treatments. Modified pre-treatment method of Princewill-Ogbonna and Ezembaukwu (2015) method was used.

Preparation of yam flour

The aerial yam flours were prepared using Princewill-Ogbonna and Ezembaukwu (2015) method (Figure 1)

Control aerial yam flour

One portion of the aerial yams were peeled manually (using knife), washed (with water), sliced into chips and sun-dried. The dried chips were milled (attrition mill), then sieved (0.3 µm aperture size) to obtain the control flour, and packed in polyethene bag.

Soaked aerial yam flour

One portion of the aerial yam were peeled manually (using knife), washed (with tap water), sliced into chips (knife), soaked (in 0.2% Meta bisulphate for 7 hours) and sun-dried. The dried chips were milled (attrition mill), then sieved (0.3 µm aperture size) to obtain the flour and was packed in polyethene bag.

Boiled aerial yam flour

One portion of the aerial yam were boiled for 30 minutes, peeled manually (using knife), sliced into chips, sun-dried and milled (attrition mill), and sieved (0.3 µm aperture size) to obtain flour and was packed in a polyethene bag.

Roasted aerial yam flour

One portion of the aerial yam were roasted on charcoal, peeled (with knife), sliced into chips, sun-dried and milled (attrition mill) and sieved (0.3 µm aperture size) to obtain the flour and was packed in polyethene bag as shown in Figure 2.

Analytical methods

Determination of proximate composition of aerial yam flour

The proximate composition (moisture, protein, fat, ash and crude fiber) contents were determined according to AOAC (2000). The total carbohydrate (CHO) was determined by

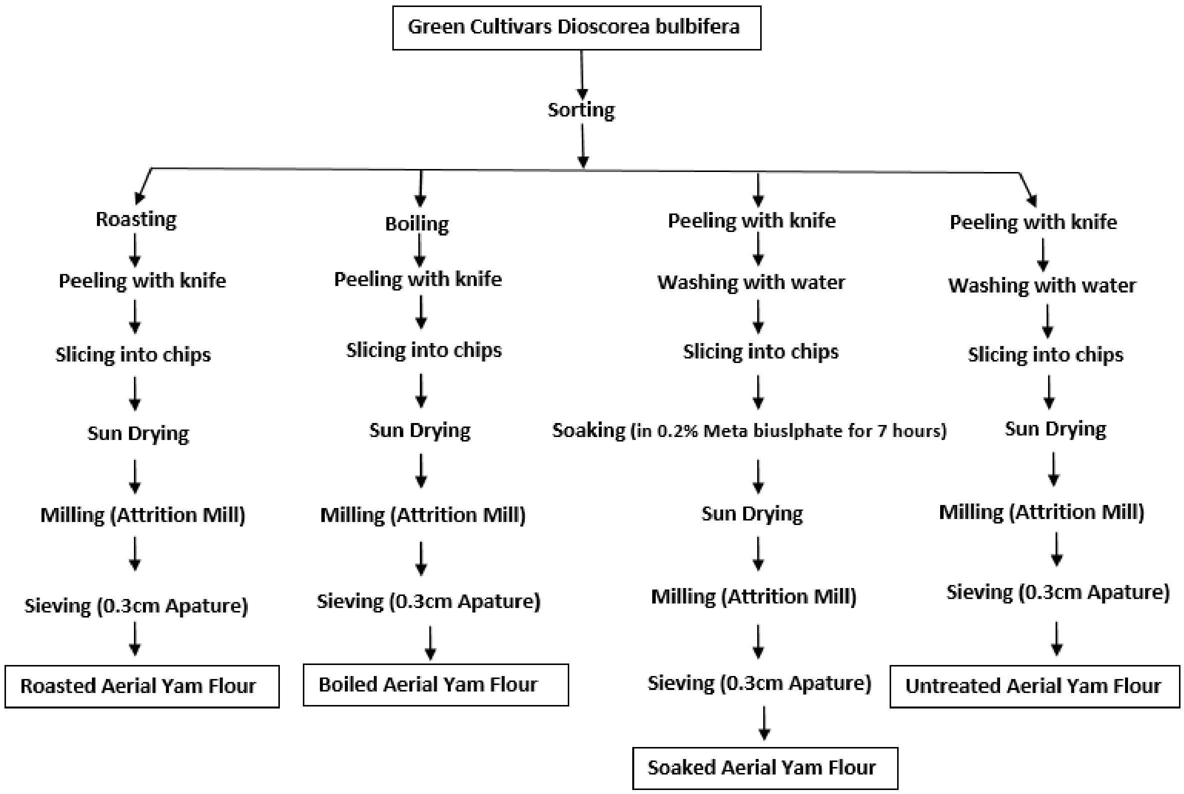

Figure 1. Modified method of production of aerial yam flour.
Source: (Princewill-Ogbonna and Ezembaukwu 2015).

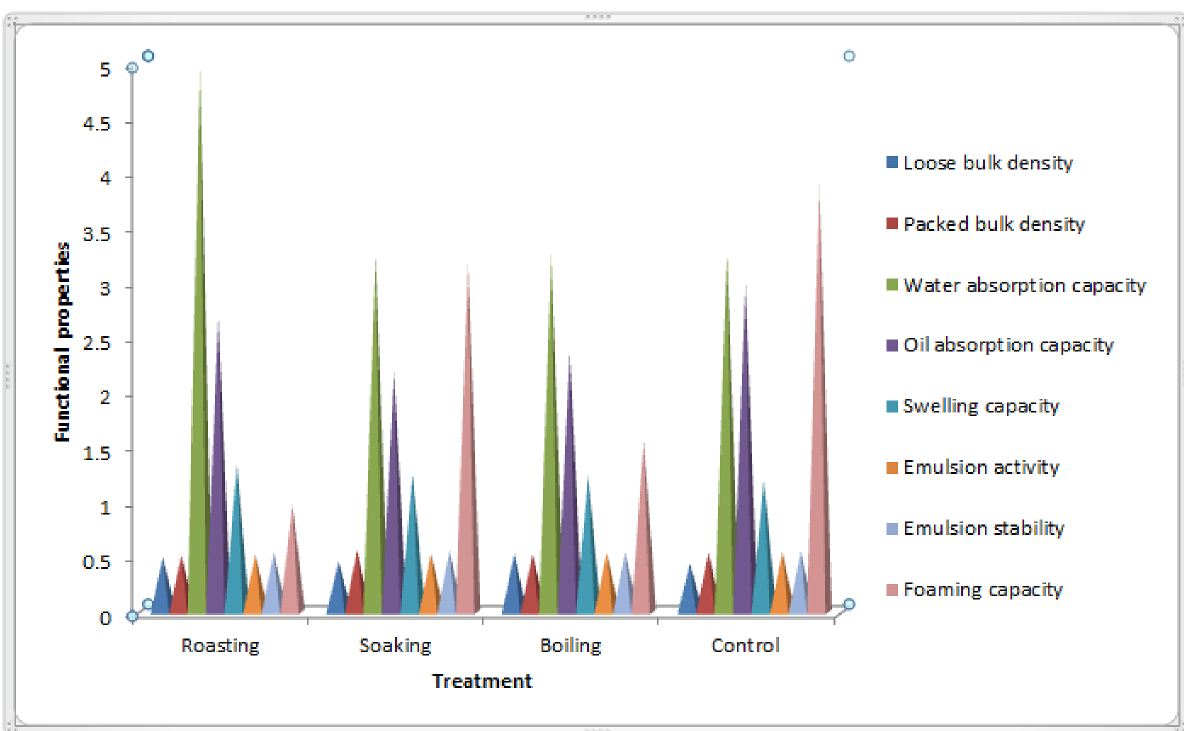

Figure 2. Functional properties of pre-treated aerial yam.

Table 1. Proximate composition of treated aerial yam flour.

Treatments	Moisture (%)	Ash (%)	Crude fibre (%)	Crude protein (%)	Fat (%)	Carbohydrate (%)	Energy (cal/g)
Roasting	9.50±0.11^{d}	2.16±0.04^{a}	1.82±0.03^{a}	5.65±0.47^{c}	2.63±0.10^{bc}	80.07±0.71^{a}	366.55
Soaking	9.88±0.03^{c}	1.88±0.28^{a}	1.77±0.01^{a}	5.69±0.05^{c}	2.91±0.18^{b}	79.50±0.08^{a}	366.95
Boiling	10.18±0.03^{b}	2.56±0.06^{b}	1.38±0.35^{c}	6.81±0.07^{b}	2.46±0.04^{c}	78.00±0.19^{b}	361.38
Control	10.37±0.35^{a}	2.37±0.04^{b}	1.64±0.02^{b}	7.59±0.08^{a}	3.86±0.06^{a}	5.81±0.05^{a}	368.34

Values are mean± standard deviation of 2 replicate. Means within each column not followed by the same superscript are significantly different ($p<0.05$) from each other.

difference: CHO =100- (% moisture + % protein + % fat + % ash).

Determination of functional property of aerial yam

Loose and pack bulk density, water absorption capacity, oil absorption capacity, swelling index, foaming capacity and stability, emulsion activity and stability were determined using the method as described by Onwuka (2005).

Determination of pasting property of aerial yam flour

The pasting properties were determined using a Rapid Visco Analyzer (Newspot Scientific, Pty Ltd, Warrie Wood NSW, Ausralia). Three and half grams (3.5 g) of the flour sample was weighed and dispensed into the test canister 25.0 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was fitted into the RVA (Rapid Visco-Analyser). The slurry was held at 50ºC for 1 minute, heated to 95ºC for 8 minutes and cooled back to 50ºC within 8 minutes, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. The parameters evaluated were peak viscosity, setback viscosity, final viscosity, pasting temperature and time to reach peak viscosity. The Visco Analyzer was switched on and the pasting performance of the flour was automatically recorded on the graduated sheet of the instrument.

Determination of phytochemical composition of aerial yam flour

Carotenoids content, alkaloids content and steroids content content of the flour were determined using Igbokwe et al. (2016) method, while the saponin content was determined by the method described by Obadoni and Ochuko (2001).

Statistical analysis

All the analyses were conducted in duplicates and in completely randomized design. The data were subjected to Analysis of Variance using Statistical Package for Social Science (SPSS) software version 15, 2007, and separated by Least Significant Difference (LSD) test at $p<0.05$ according to. Nancy et al. (2005).

RESULTS AND DISCUSSION

Proximate composition of pre-treated aerial yam (*Dioscorea bulbifera*) flours

The proximate analysis of different Aerial Yam (*Dioscorea bulbifera*) flour samples are shown in Table 1. The moisture, ash, crude fibre, crude protein carbohydrate and fat ranged from 9.50±0.11 to 10.37±0.35, 1.88±0.28 to 2.56±0.06, 1.38±0.35 to 1.82±0.03, 5.65±0.04 to 7.59±0.06, 75.81±0.05 to 80.07±0.71 and 2.46±0.04 to 3.86±0.06%, respectively. The roasted-dried aerial yam flour had the highest values for crude fibre (1.82±0.03%) and carbohydrate (80.07±0.71%). The effects of the pre-treatments are significant, at $p<0.05$. The moisture content reflects the quantity of solid matter present and the rate of spoilage is also closely related to the amount of moisture present (Sanfal et al., 2013), thereby showing that the pre-treated aerial yam flour has low spoilage capacity owing to its low moisture content. These values obtained varies slightly with other related work (Ojinnaka *et* al., 2017) which could be due to differences in soil and climatic factors. Presence of fat contributes to the palatability of the crops while high value of carbohydrate indicates that it is a high source of energy.

Functional properties of aerial yam (*Dioscorea bulbifera*) flour Samples

The functional properties of aerial yam flour samples are shown in Figure 2 and 3. The loose bulk density, packed bulk density, water absorption capacity, oil absorption capacity, swelling capacity, emulsion stability and foaming capacity ranged from 0.44±0.03 to 0.50±0.01, 0.52±0.01 to 0.56±0.05, 3.25±1.20 to 4.91±1.54, 2.18±0.25 to

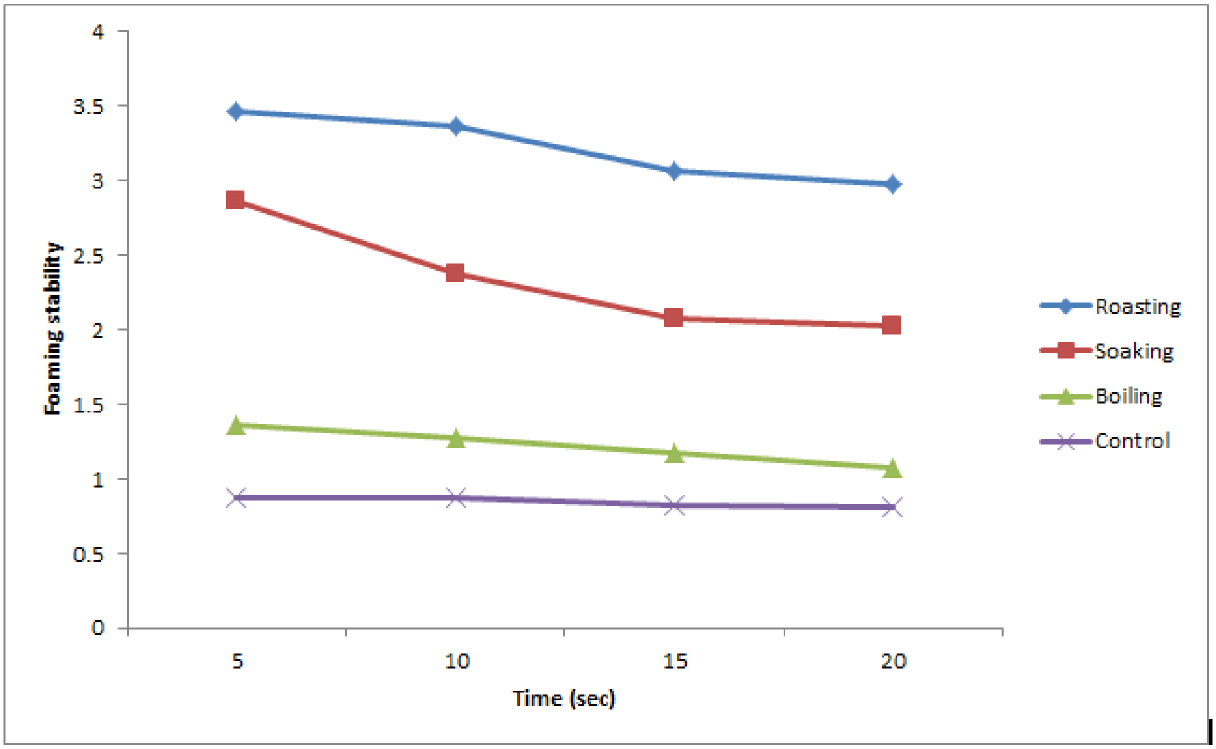

Figure 3. Foaming stability of treated aerial yam flour.

2.97±0.33, 1.20±0.08 to 1.34±0.07, 0.54±0.54 to 0.56±0.56 and 0.98±0.25 to 3.87±0.47 g/cm^3, respectively. The roasted-dried sample had the highest values in loose bulk density (0.50±0.01 g/cm^3), water absorption capacity (4.91±1.54 g/cm^3) and swelling capacity (1.34±0.0747 g/cm^3), while the soaked-dried sample had the highest values for packed bulk density (0.5647±0.050147 g/cm^3) and emulsion stability (0.56±0.56 g/cm^3). The pre-treatments were significant $p<0.05$, for all the assessed parameter.

The functional properties of food are defined as properties reflecting complex interactions between the composition, structure, conformation and physiochemical properties components (Kohnhorst et al., 1990). Low bulk density could be an advantage in the digestion of food products and also in transportation cost, while relatively high bulk density could also be an advantage particularly for food products with high dispensability and reduced paste thickness (Udensi and Eke, 2000). The increase in the water absorption, and swelling capacities by roasting could add to the potential of *D. bulbifera* yam flour in food processing. High water absorption flour have been found to be suitable for baking (Kohnhorst et al., 1990) and high oil absorption flour shows improve flavour and mouth feel of baked foods (Jacques et al., 2017). High swelling capacity of flour could be an advantage in dough development in baked foods. Presence of foams indicates improvement in texture, consistency and appearance of foods (Akubor, 2007). The emulsion activity could be due to the presence of protein in flour which improves its ability to mix with oil and water.

The pasting properties of the aerial yam flour samples are shown in Figure 4. The peak, trough, breakdown, final viscosity, set back and peak time ranged from 53.88±0.53 to 148.13±1.12, 49.34±0.59 to 142.92±0.47, 4.54±0.57 to 12.88±5.01, 73.42±0.35 to 192.38±16.20, 23.92±0.83 to 58.42±7.07 and 7.00±0.00 RVU, respectively (Figure 4). The soaked sample showed highest value for peak (148.13±1.12 RVU) and trough (142.92±0.47 RVU), while the roasted sample showed highest values for breakdown (7.21±0.65RVU), final viscosity (186.00±2.94RVU) and set back (45.08±2.47RVU). The trough is an indication of degree of gelation level of cooked starch. Relatively, high breakdown value could be desirable in products that should be kept at high temperature for a long time (Princewill-Ogbonna and Ezembaukwu, 2015). Higher set back values are synonymous to reduced dough digestibility while lower setback during the cooling of the paste indicates lower tendency for retro gradation (Princewill-Ogbonna and Ezembaukwu 2015), while the peak time can be related to cooking time. The effects of the respective pre-treatments on the pasting properties of *D. bulbifera* flours could be an important index in determining the cooking and baking qualities of their flours

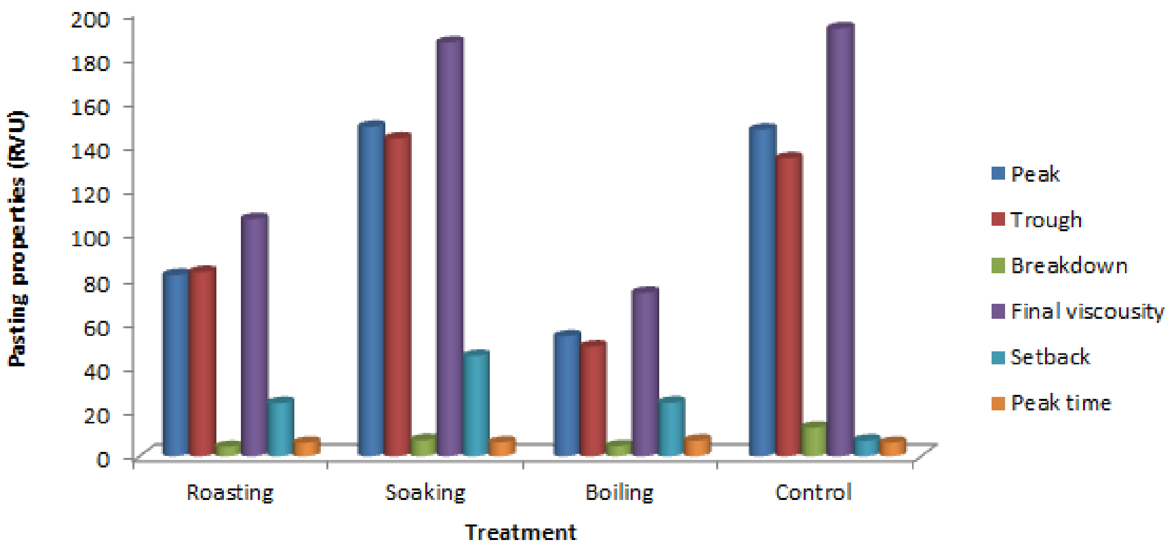

Figure 4. Pasting properties of treated aerial yam flour.

Table 2. Phytochemical composition of treated aerial yam flour.

Treatments	Carotenoid (ug/g)	Saponin(mg/g)	Steroid(mg/g)	Alkaloid(mg/g)
Roasting	4.5±0.37[a]	0.39±0.01[b]	0.60±0.00[a]	0.12±0.01[b]
Soaking	4.17±0.03[a]	0.35±0.01[b]	0.50±0.21[b]	0.16±0.01[ab]
Boiling	2.62±0.03[b]	0.54±0.03[b]	0.47±0.03[b]	0.19±0.01[a]
Control	2.77±0.21[b]	1.27±0.30[a]	0.64±0.01[a]	0.16±0.03[ab]

Values are mean± standard deviation of 2 replicate. Means within each column not followed by the same superscript are significantly different ($p<0.05$) from each other.

as pointed out by Adeniji et al. (2010).

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

The phytochemical composition of aerial yam flour samples is shown in Table 2. The carotenoid, saponin, steroid and alkaloid ranged from 2.62±0.03 to 4.71±0.03, 0.35±0.01 to 1.27±0.03, 0.47±0.03 to 0.64±0.01 and 0.12±0.01 to 0.19±0.01%, respectively. The soaked-dried sample had the highest values for carotenoid (4.71±0.03%), and lowest value for saponin (0.35±0.01%). The boiled-dried sample showed lowest values for steroid (0.47±0.03%) and the roasted-dried sample showed lowest value for alkaloid (0.12±0.01%). Most phytochemicals including carotinoid, saponin and flavonoid are anti-oxidants, lower cholesterol, inhibit tumor formation, decrease tumor formation, decrease inflammation and protect against cancer and heart diseases (Onimawo and Akubor, 2012). The relative increase in the carotinoid level of the roated sample could be an advantage in increasing the β-carotene which have been found to functions as a free-radical-trapping agent and single oxygen quencher and have anti-mutagenic, chemo-preventive, photoprotective and immune enhancing properties (Krishan et al., 2012; Sanful et al., 2013).

Conclusion

The research work had proved positive as the essential and human body needed components were improved while the possible harmful ones were reduced by the pre-treatment of *D. bulbifera* yam flours. Roasting has been noted to improve the fibre and carotenoid content with water and oil absorption capacity of the flour but reduces the levels of saponin and alkaloid of the flour which could pose harm to the consumer at relative higher concentration. However, soaking had notable improvement on pasting qualities of the flour, and could therefore be recommended for production of viscous related food products.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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