American Journal of Food Science and Technology, 2020, Vol. 8, No. 4, 161-165
Available online at http://pubs.sciepub.com/ajfst/8/4/5
Published by Science and Education Publishing
DOI:10.12691/ajfst-8-4-5

Soaking Effects of Chips from Two Bitter Yam Species on Chemical and Functional Compositions of the Flour

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Received June 10, 2020; Revised July 11, 2020; Accepted July 20, 2020

Abstract Physico-chemical properties of foods are greatly influenced by some processing methodologies which thus affects the utilization of these foods. This research studied the soaking effect of two species of bitter yam chips *D. dumentorum* and *D. hispida* in water for for 6, 12, 18 and 24 h before oven drying and size reduction to flour. The various flour samples and their respective controls were analyzed for functional properties, vitamin C, beta carotene, phosphorus, calcium, pH and anti-nutrient (alkaloid and tannin) using standard methods. The results depicts that in flour samples of *D. hispida* and *D. dumetorum*, respectively, there were significant increase (from fresh to 24 h soaked samples) in pH values from acidic to near neutrality (5.2 - 7.5; 4.8 - 7.9), decrease in anti-nutritional factors (tannin (0.48 - 4.02%; 1.37 -15.83%) and alkaloid (nil; 0.14 - 1.26%), vitamin C (1.02 - 1.95; 1.22 - 2.39 mg/100g) and beta carotene (1.81 - 3.56; 4.24 - 5.79 mg/100g) and minerals (phosphorus (1.40 - 3.44; 1.78 - 4.50 mg/100g) and calcium (16.4 - 24.80; 4.23 - 28.16 mg/100g) with increase in soaking periods (h) due to leaching out of these nutrients in soaking water. Water/oil absorption capacity, swelling index, least gelation capacity and viscosity of samples decreased with increase in soaking time (h), while gelatinization temperature of samples increased with increase in soaking time (h). This shows that there was modification in compositions of these flours depending on the soaking time applied which provided information on utilization of soaking in water processes in optimizing the properties of bitter yam chips in flour production.

Keywords: *physico-chemical, soaking, bitter yam flour*

Cite This Article: Francis Chigozie Okoyeuzu, Rachael Chinwendu Eze, and Ngozi Chioma Okoronkwo, "Soaking Effects of Chips from Two Bitter Yam Species on Chemical and Functional Compositions of the Flour." *American Journal of Food Science and Technology*, vol. 8, no. 4 (2020): 161-165. doi: 10.12691/ajfst-8-4-5.

1. Introduction

Yam (*Dioscorea* spp. L) is a vegetatively propagated tuber food crop, a polyploidy that belongs to the family *Dioscoreaceae* and is classified among monocotyledonous herbaceous annual or perennial climbing or trilling crop plants [1]. Bitter yam is known as "Ji una" or Ji ona" in Ojoto and many Igbo speaking area in the south-eastern part of Nigeria, where it is regarded as adult food [2]. The crop produces underground tubers and or aerial tubers, bulbils and rhizomes which act as a source of food, feed and drugs or medicines. *Dioscorea hispida* is Asiantic bitter yam found in India, South China and new Guinea containing alkaloid dioscorine (Malayan species) which is toxic to man and animals, and these alkaloid are water soluble poison which can be detoxified by soaking boiled tubers in running water [3]. The most processed traditional yam product is yam flour [4] which contains protein carbohydrates and trace amounts of minerals and vitamins. Even with the potential of using bitter yam in bakery and pharmaceutical industries, it has no industrial application [5]. Yam flour is traditionally processed by peeling, sometimes slicing parboiling in hot water (65°C) for varied time followed by steeping for 13 - 24 h by sun drying to give a dry yam which is milled into flour 'Elubo'. Bitter yam is rich in phyto-nutrients, including proteins [6,7], yet it remains an underutilized tropical tuber [8]. The reasons for the limited use of bitter yam include, the unpalatable bitter taste and high post-harvest hardening of the tubers [6]. To prevent the high post-harvest hardening, the tubers were dried and milled into flour [2]. In this regard, there is need for further simple processing method(s) that may improve on the traditional method of drying and milling [2]. [3] who reported that increased cooking duration improved the nutritional and phytochemical properties of the bitter yam formed the basis of this study in investigating an alternative and cheaper/ affordable method of reducing the bitter principles in bitter yam tubers. This research studied the soaking effect of two species of bitter yam chips *D. dumentorum* and *D. hispida* in water.

2. Materials and Methods

The two bitter yam species were procured from cultivated farm lands and Nsukka Ogige Main Market, Enugu State, South-eastern Nigeria. The equipment utilized were obtained from the laboratory of Food Science and Technology Department, University of Nigeria, Nsukka, Enugu State. All the chemicals used were also of analytical qualities. Best quality of each of the bitter yam species were sorted, washed to remove sands, sliced, rewashed and weighed. The chips were thereafter divided into 5 equal parts each, while 4 parts were respectively soaked into clean water for 6, 12, 18 and 24 h and drained, 1 part was unsoaked and served as control. Altogether the 5 parts each were individually dried to a constant weight in a moisture extraction oven (Gallenkamp 1H-100) set at 50°C, cooled for 40 min and milled in a laboratory mill (Thomas Wiley mill model ED-5) into flour. The separate flour samples were packaged in a properly labelled airtight container prior to analysis.

2.1. Chemical, Functional and Statistical Analysis

Vitamins (vitamin C and beta carotene), minerals (phosphorus and calcium) and anti-nutrients (tannins and alkaloid) were determined by methods of AOAC [9] and pH was read from a pH meter (model 20 Denvier instrument). Collected data were analysed using statistical product for service solution SPSS/PC+, Version 20.0 (SPSS Inc., Chicago, IL, USA). Analysis of Variance (ANOVA) was employed for comparison among the groups. Duncan's new multiple range test (DNMRT) was used to compare the treatment means and accepted at 5% significance level.

3. Results and Discussion

3.1. Effect of Soaking on Vitamins and Minerals

Results as presented in Figure 1 shows that soaking had significant ($p < 0.05$) difference on vitamin and mineral contents of all flour samples which decreased with increase in soaking time (h). Vitamin C content of D. *hispida* flour samples ranged from 1.02 to 1.95 mg/100g. 24 h soaked sample had lowest vitamin C value of 1.02 mg/100g while fresh (control/0 h) sample had 1.95 mg/100g. Likewise, beta carotene content of D. *hispida* flour samples ranged from 1.81 to 3.56 mg/100g. 24 h soaked sample had lowest beta carotene value of 1.81 mg/100g while fresh (control/0 h) sample had 3.56 mg/100g.

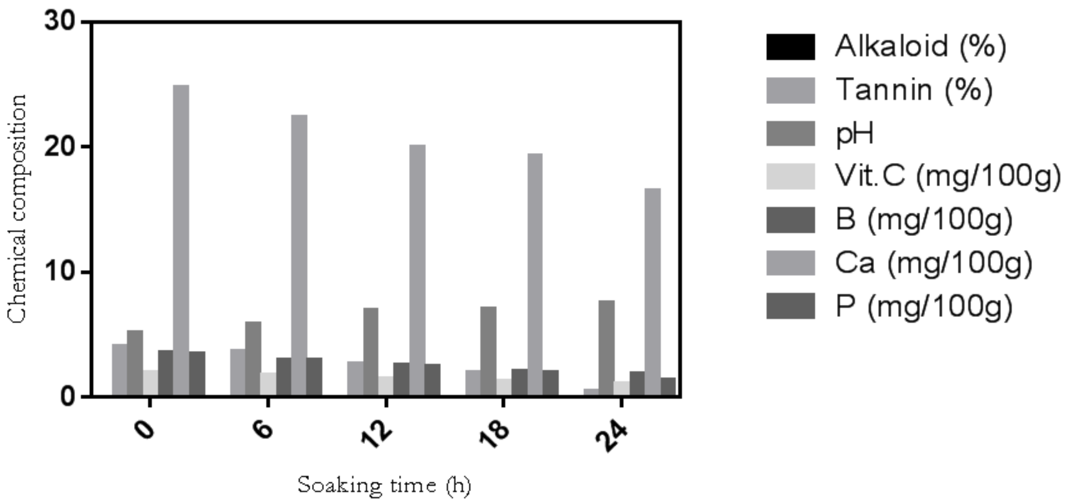

Figure 1. Chemical com positions of D.*hispida* flour samples (Where; Vit. C = vitamin C, B = beta carotene, Ca = calcium and P = phosphorus)

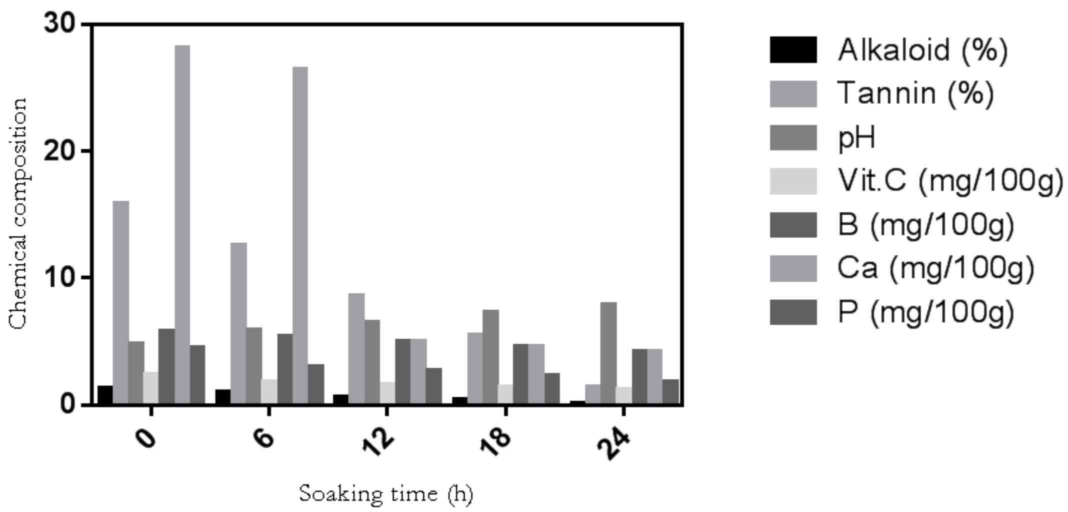

Figure 2. Chemical compositions of D.*dumentorum* flour sample (Where; Vit. C = vitamin C, B = beta carotene, Ca = calcium and P = phosphorus)

Also, calcium content of *D. hispida* flour samples ranged from 16.43 to 24.8 mg/100g. 24 h soaked sample had lowest calcium value of 16.43 mg/100g while fresh (control/0 h) sample had 24.8 mg/100g. Phosphorus content of *D. hispida* flour samples ranged from 1.4 to 3.44 mg/100g. 24 h soaked sample had lowest calcium value of 1.4 mg/100g while fresh (control/ 0 h) sample had 3.44 mg/100g. These reductions in nutrients could be due to leaching out in soaking water since vitamins and minerals are soluble in water.

Similarly, data in Figure 2 shows that vitamin C and beta carotene contents of *D. dumetorum* flour samples ranged from 1.22 to 2.39 mg/100g and 4.24 to 5.79 mg/1100g, respectively. 24 h soaked samples had lowest vitamin C and beta carotene values of 1.22 and 4.24mg/100g while their fresh (controls/0 h) samples had 2.39 and 5.79 mg/100g, respectively. These reductions in nutrients could be due to leaching out in soaking water since vitamins and minerals are soluble in water.

3.2. Effects of Soaking on Anti-nutrients and pH

Result presented in Figure 1 depicts that alkaloid was not detected in flour samples of *D. hispida* while significant ($p < 0.05$) difference was observed on samples of *D. dumetorum* and ranged from 0.14 to 1.26 mg/ 100g (Figure 2) with samples of 24 h soaking having lowest value of 0.14 mg/100g, while 0 h soaked samples had higher value of 1.26 mg/100g. These nutrients decreased with increase in soaking period (h). Similarly, significant ($p < 0.05$) difference in tannin contents was observed on samples of *D. hispida* and ranged from 0.48 to 4.02 mg/ 100g (Figure 1) with samples of 24 h soaking having lowest value of 0.48 mg/100g, while 0 h soaked samples had higher value of 4.02 mg/100g. However, tannin contents of *D. dumetorum* had higher significant $p < 0.05$ difference than that of *D. hispida* and ranged from 1.37 to 15.83 mg/100g (Figure 2). Flour samples soaked for 24 h had lowest values of 1.37 mg/100g while that of 0 h soaked samples had highest value of 15.83 mg/100g. These reductions could be as result of leaching of these nutrients in soaking water. It was also observed in Figure 1 and Figure 2 that pH values of both flour samples increased from acidic levels to above neutrality with increase in soaking time (h). pH values of *D. hispida* ranged from 5.2 to 7.5 with 24 h soaked samples having highest value of 7.5 while 0 h soaked samples had lowest value of 5.2. Similarly, pH values of *D. dumetorum* ranged from 4.80 to 7.90 with 24 h soaked samples having highest value of 7.90 while 0 h soaked samples had lowest value of 4.80.

3.3. Effects of Soaking on Functional Properties

Data presented in Figure 3 and Figure 4 shows that soaking significantly $p < 0.05$ affected the functional properties of flour samples of *D. hispida* and *D. dumetorum*, respectively, since their values decreased (from 0 - 24 h) with increase in soaking time (h) except for gelatinization temperature which increased (from 0 - 24 h) with increase in soaking time (h). The functional properties of *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) flour samples, respectively ranged as follows; water absorption capacity (WAC) (0.71 - 1.69; 0.90 - 2.13 g/g) with 24 h soaked samples flour samples having the lowest values of 0.71 and 0.90 g/g and fresh (0 h soaked) samples having highest values of 1.69 and 2.13 g/g, respectively. Water absorption characteristics represent the ability of a product to associate with water conditions where water is limiting such as dough and pastes.

Oil absorption capacity (OAC) ranged from (0.86 - 1.79; 0.70 - 1.79 g/g) with 24 h soaked samples flour samples having the lowest values of 0.86 and 0.70 g/g and fresh (0 h soaked) samples having highest values of 1.79 and 1.79 g/g, respectively in *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) species. The fat binding capacity of bitter yam protein would find useful application in ground meat formulations, wheat replaces and extenders.

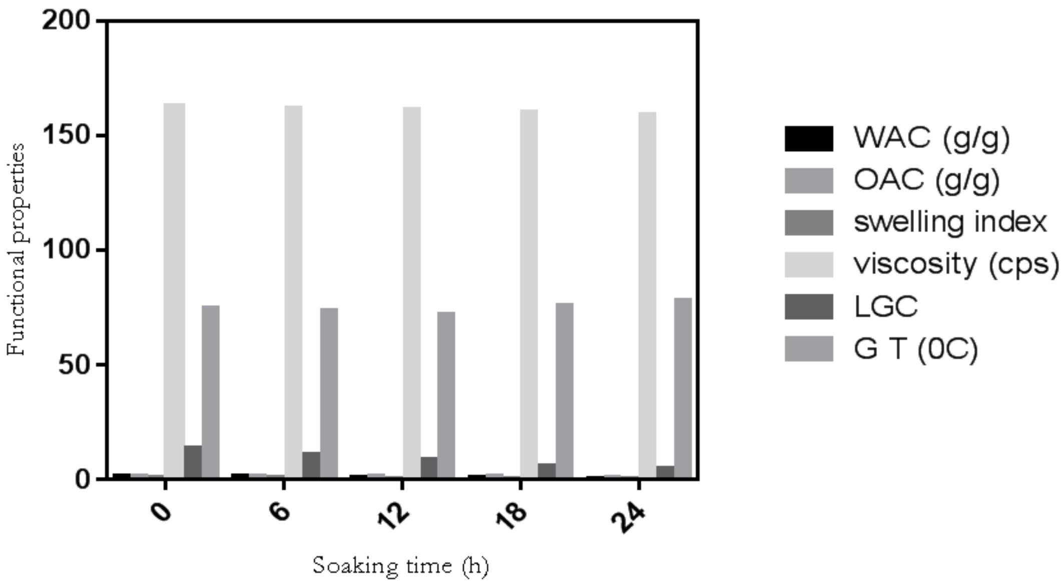

Figure 3. Functional properities of D.*hispida* flour samples (Where; WAC: water absorption capacity, OAC: oil absorption capacity, LGC: least gelation capacity, GT: gelatinization temperatur)

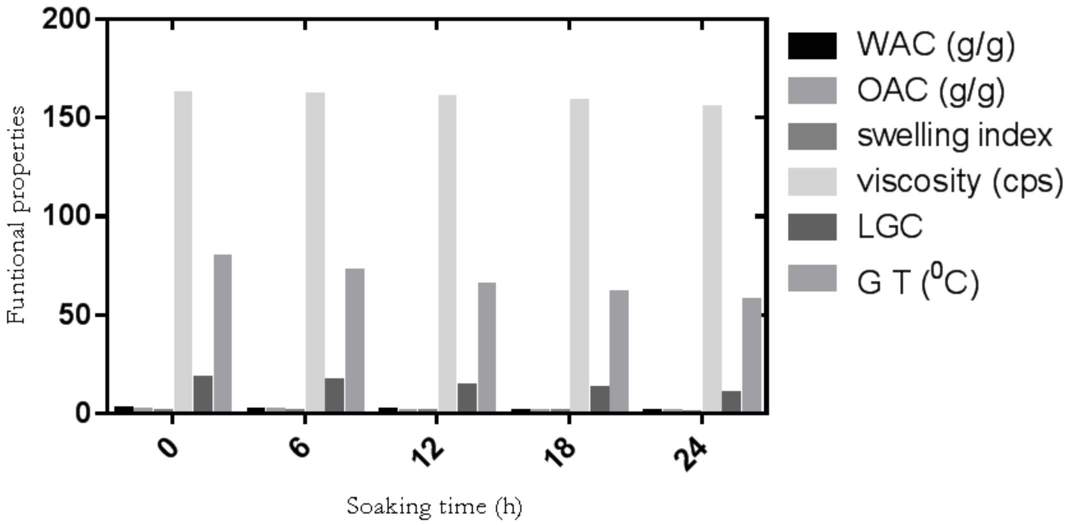

Figure 4. Functional properties of D.*dumentorum* flour samples (Where; WAC: water absorption capacity, OAC: oil absorption capacity, LGC: least gelation capacity, GT: gelatinization temperature)

Swelling index (SI) ranged from (0.32 - 1.24; 0.58 -1.24) with 24 h soaked samples flour samples having the lowest values of 0.32 and 0.58 g/g and fresh (0 h soaked) samples having highest values of 1.24 and 1.24 g/g, respectively in *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) species. This decrease could be due to saturation effect following increasing exposure of the samples to the action of water [2]. One explanation of greater swelling volume from soaked yam slices compared to the control slices is the finer flour articles size [10]. Egbuonu *et al*. [2] therefore suggested that processing by soaking in water is not recommended when the target is to increase the swelling index of the resultant bitter yam flour.

Viscosity ranged from (159.0 -162.0; 155.0 - 162.0 cps) with 24 h soaked samples flour samples having the lowest values of 159.0 and 155.0 cps and fresh (0 h soaked) samples having highest values of 162.0 and 162.0 cps, respectively in *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) species. This reductions could be due to hydrolysis of starch granule which increased with increased soaking period, since the lower the water content the higher the viscosity [11].

Least gelation capacity (LGC) ranged from (5 - 14; 10 - 18) with 24 h soaked samples flour samples having the lowest values of 5.0 and 10.0 and fresh (0 h soaked) samples having highest values of 14.0 and 18.0, respectively in *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) species. Similarly, these reductions could be due to hydrolysis of starch granule which increased with increased soaking period.

Gelatinization temperature ranged from (75 - 78; 57 - 79°C) with 24 h soaked samples flour samples having the lowest values of 75 and 57°CC and fresh (0 h soaked) samples having highest values of 78 and 79°C, respectively in *D. hispida* (Figure 3) and *D. dumetorum* (Figure 4) species.

4. Conclusion

The results showed that subjecting bitter yam slices to soaking prior to drying reduced both the anti-nutritional composition which are the main components of the bitter principle. Soaking in water reduced the nutritional compositions of the flour samples since they are water soluble. The fat binding capacity of bitter yam protein would find useful application in ground meat formulations, wheat replaces and extenders. Processing by soaking in water is not recommended when the target is to increase the swelling index of the resultant bitter yam flour.

Acknowledgements

Sincere appreciation goes to the department of Food Science and Technology, University of Nigeria, Nsukka for providing us with all the necessary laboratory equipment and chemicals utilized in the course of the study.

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