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Effect of Cooking and Soaking on the Proximate Composition, Anti-Nutrient and Functional Properties of Bitter Yam

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ABSTRACT

The effect of cooking and soaking on the functional properties of bitter yam tubers were investigated. Peeled yam slices were subjected to two treatments – cooking, soaking overnight and subsequent cooking. Thereafter, the treated tubers were oven-dried. Proximate analysis, anti-nutrient assessment and functional properties determination were conducted using standard procedures. Proximate and functional properties analysis revealed that the treatments significantly affected the nutrient composition of the bitter yam samples. Studies on the anti-nutrients indicated a significant reduction in their levels when compared to the raw sample. It is concluded from this study that cooking on one hand, and soaking and cooking on the other hand effected significant reductions in the levels of anti-nutrients and affected the functional properties of the bitter yam samples.

Keywords: *Bitter yam, functional properties, proximate composition, anti-nutrient, soaking, cooking.*

INTRODUCTION

Dioscorea (true yam) is a large genus containing more than 600 species, of which only seven are edible (Stennett *et al*., 2014). Trifoliate yam *(Dioscorea dumetorum)* is an under-exploited but high-yielding yam species which is nutritionally superior to the commonly consumed yams with high protein and mineral levels. It has higher starch digestibility, but contains some anti-nutrients which result in its characteristic bitterness (Akinoso *et al*., 2016). Thus, the utilization of this yam is limited by the presence of the toxic anti-nutrients, while the presence of enzyme-inhibitors could impair the digestion of starch and protein thereby limiting their utilization as food (Polycarp *et al*., 2012). This is because anti-nutrients in foods are responsible for deleterious effects related to the absorption of nutrients and micronutrients. Hence, the manipulation of processing conditions and/or removal of certain unwanted components of foods may be required (Shahidi, 1997). Montagnac *et al*. (2008) identified soaking in water and sun drying, while Akande and Fabiyi (2010) discussed cooking (boiling) as methods for inactivating anti-nutritive factors in foods. Slicing, soaking and boiling, sometimes with the addition of salt, or tying he sliced tuber in a jute sack and leaving in running water for 3 days have been suggested as suitable methods for removing toxic and/or bitter compounds in trifoliate yam that are believed to be injurious to health (Fasaanu *et al.*, 2013). All these procedures are geared towards enhancing the safety of consumers upon eventual consumption of the tuber, as well as improving the functional attributes of the tuber for other food applications.

This study is aimed at investigating the effect of cooking and soaking on the proximate, anti-nutrient and functional properties of bitter yam.

MATERIALS AND METHODS

Materials

Wholesome tubers of trifoliate yam were obtained from the Umuahia in Abia State, South -Eastern Nigeria. The equipment and apparatuses used were sought from the Department of Food Technology, Federal Polytechnic Nekede, Owerri, and Imo State. All chemical used were of analytical grade.

Methods

***Samples Preparation**:* The trifoliate yam tubers were processed into flour according to the procedure adopted by Akinoso *et al.* (2016) with slight modifications. The trifoliate yam tubers were sorted and cleared. Thereafter, the tubers were carefully peeled, washed and sliced. The slices were divided into three equal portions. A portion was soaked in water for 12 hours, cooked for 1 hour, drained and cooled for 20 minutes, oven-dried at 50^{o}C for 48hours and milled with a hammer mill. This was followed by sieving using a 250μm sieve and packaging of the collected flour. The second portion was cooked directly after slicing for 1 hour and had the other procedures conducted sequentially. The third portion was dried after slicing and milled. All the flour samples were packaged for further analysis.

ANALYTICAL PROCEDURE

Proximate analysis

The samples were analyzed in triplicates, according to the methods adopted by Afoakwa and Sefa-Dedeh (2001). The AOAC (1990) approved methods for moisture, ash; crude fat, crude protein and crude fibre were used. The carbohydrate content was estimated by difference.

Functional properties

The methods adopted by Egbuonu *et al.* (2014) and Onwuka (2005) were used.

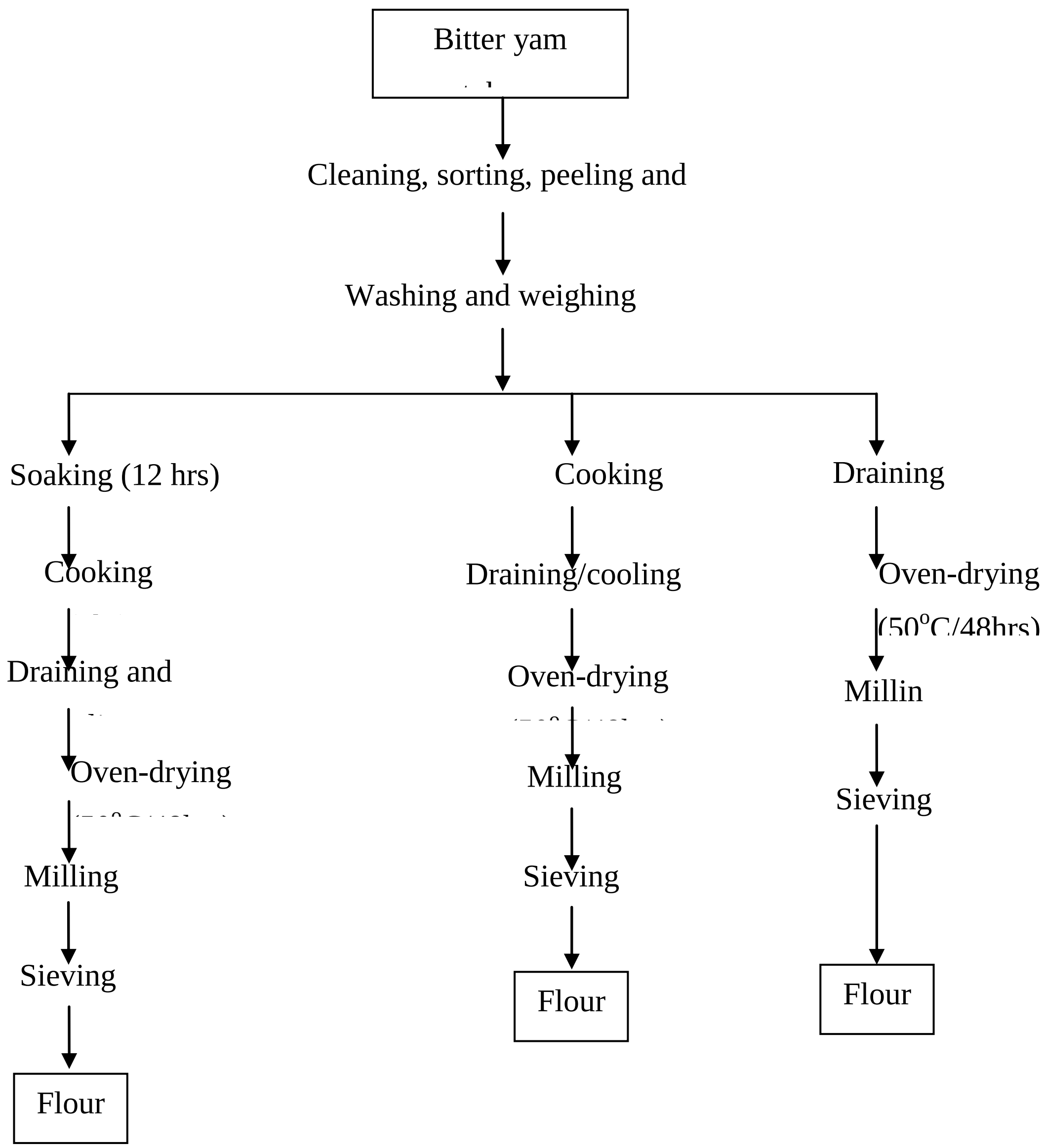

Fig. 1: Flow chart for the production of bitter yam tuber flours.

RESULTS AND DISCUSSION

Table 1: Proximate Composition of Bitter Yam Flour Samples

Samples	Ash (%)	Fat (%)	Moisture (%)	Crude fibre (%)	Protein (%)	CHO (%)
RBY	$2.25^{a} \pm 0.05$	$0.71^{a} \pm 0.01$	$6.10^{a} \pm 0.07$	$2.04^{a} \pm 0.04$	$11.14^{a} \pm 0.01$	$77.35^{c} \pm 0.27$
CDY	$1.91^{b} \pm 0.43$	$0.64^{b} \pm 0.02$	$5.25^{c} \pm 0.08$	$1.88^{b} \pm 0.02$	$10.30^{b} \pm 0.30$	$80.09^{b} \pm 0.18$
SOC	$1.74^{b} \pm 0.02$	$0.58^{c} \pm 0.02$	$5.65^{b} \pm 0.05$	$1.73^{c} \pm 0.03$	$9.41^{c} \pm 0.01$	$81.63^{a} \pm 0.12$
LSD	0.35	0.03	0.11	0.04	0.25	0.28

Values are means ± standard deviation of the given parameters of each sample. Sample means with different Superscripts are significantly different at $p<0.05$.

KEY: RBY – Raw bitter yam
CDY – Cooked directly
SOC – Soaked and cooked

Table 2: Anti-nutrient Composition of Bitter Yam Flour Samples (mg/100g)

Samples	Alkaloid	Flavonoid	Saponin	Tannin	Phenol
RBY	$3.08^{a} \pm 0.02$	$0.66^{a} \pm 0.04$	$3.36^{a} \pm 0.04$	$0.32^{a} \pm 0.02$	$1.83^{a} \pm 0.03$
CDY	$2.33^{b} \pm 0.03$	$0.51^{b} \pm 0.06$	$2.92^{b} \pm 0.02$	$0.28^{b} \pm 0.02$	$1.16^{b} \pm 0.02$
SOC	$0.67^{c} \pm 0.03$	$0.61^{a} \pm 0.01$	$1.52^{c} \pm 0.02$	$0.24^{b} \pm 0.05$	$1.15^{b} \pm 0.05$
LSD	0.04	0.06	0.04	0.05	0.05

Values are means ± standard deviation of the given parameters of each sample. Sample means with different superscripts are significantly different at $p<0.05$.

KEY: RBY – Raw bitter yam
CDY – Cooked directly
SOC – Soaked and cooked

Table 3: Functional Properties of Bitter Yam Flour Samples

Samples	Bulk density (g/ml)	OAC (g/g)	WAC (g/g)	Foam capacity
RBY	$0.57^{a} \pm 0.02$	$2.51^{c} \pm 0.01$	$3.74^{a} \pm 0.01$	$29.13^{a} \pm 0.03$
CDY	$0.64^{a} \pm 0.34$	$2.64^{b} \pm 0.04$	$3.12^{c} \pm 0.02$	$24.22^{b} \pm 2.81$
SOC	$0.68^{a} \pm 0.02$	$2.84^{a} \pm 0.04$	$3.34^{b} \pm 0.02$	$26.23^{b} \pm 1.66$
LSD	0.28	0.04	0.05	2.66

Values are means ± standard deviation of the given parameters of each sample. Sample means with different superscripts are significantly different at $p<0.05$.

KEY: RBY – Raw bitter yam
CDY – Bitter yam, cooked directly
SOC – Bitter yam, soaked and cooked
OAC – Oil Absorption capacity
WAC – Water Absorption capacity.

Proximate Composition

Significant differences existed amongst the floor samples on the basis of moisture (Table 1). The raw bitter your flour sample had the highest value (6.10%) while the sample which was cooked directly had the least value (5.25%). There values are well within the range (4.02 - 8.17%, raw) obtained by Polycarp *et al.* (2012). The moisture levels fall within the acceptance value of not more than 10% for extended storage of flour. This implies that the flour samples, if well kept, would not be susceptible to spoilage by microbes, (Okaka, 2010). The percentage ash content of the test sample ranged from 1.74% to 2.25%. The raw trifoliate yam flour had the highest value of 2.25% while that which was soaked for 12 hours and cooked had the least value (1.74%). This reduction can be attributed to losses due to leaching of soluble components into the soaking and boiling water (Onuegbu *et al*, 2013). The percentage fat content of the flour samples was between 0.58-0.71% with the soaked and cooked sample having the least value and that from the raw sample having the highest value. The result agrees with the findings of Uzoukwu *et al*, (2015) on trifoliate yam studies (0.32-0.80%) implying that trifoliate yam is not a very good source of fat. The percentage crude fibre of the samples ranged between 1.73 and 2.04%. These values are slightly lower than those obtained by Uzoukwu *et al,* (2015a) (2.46-3.13%) in their investigations on trifoliate yam soaked in trona solution. This trend may have resulted from the processing method used or species diversity. Nonetheless, it suggests that trifoliate yam has some indigestible components which would aid in gastro-intestinal bulk motility (Nzelu *et al*, 2012). The protein content (%) of the trifoliate yam flour samples had values ranging between 9.41-11.41%. There were significant differences in the protein content with the raw sample exhibiting the highest value, following by the one cooked directly and the sample soaked first prior to cooking. The values obtained are quite higher than those reported by Martin *et al*. (2010) (7.44 - 8.00%) for *Dioscorea alata* and *Dioscorea cayenensis-rotundata* complex, confirming Akinoso *et al's* (2016) assertion that trifoliate yam is nutritionally superior to other yam varieties with generally higher protein values. The trend observed, however, shows a gradual decline in the protein content with cooking and then soaking and cooking. This is likely due to the dissolution of soluble components as a result of thermal hydrolysis of large molecules into smaller ones and subsequent leaching of such compounds into the boiling water (Onuegbu *et al*, 2013). The percentage carbohydrate content of the samples had values between 77.35-81.63%. The percentage carbohydrates seemed to increase with the applied treatments. This correlates well with the outcomes of studies by Uzoukwu *et* *al.,* (2015a) (77.24-82.25%) on trifoliate yam with identical trends indicative of incremental carbohydrate levels associated with heat- treatment as a result of the decline in the proportions of the other nutrients. Nonetheless, trifoliate yam is a good source of calories.

Anti-nutrient composition

Anti-nutrients are compounds which can bind to nutrients directly or can compete biochemically for active sites for nutrients activity. They must be removed from foods before consumption, otherwise nutrition and health are impaired (Okaka, 2010). Significant differences existed for alkaloids, flavonoids, saponin, tannin and phenols in the trifoliate yam flour samples as showed in Table 2. The alkaloid content (mg/100g) decreased significantly from 3.08mg/100g in the raw trifoliate yam to 0.67mg/100g in the sample which was soaked and cooked. The sample cooked directly had a high value (2.33mg/100g) though it exhibited a reduction when compare to the raw form. High alkaloid concentration in foods results in direct binding to neuroreceptors and interference with neurotransmitter metabolism (cholinesterase inhibition) in mammals with adverse consequences. (Kennedy & Wightman, 2011). The flavonoid content was highest (0.66mg/100g) in the raw trifoliate yam flour. Cooking directly affected the highest reduction (0.51mg/100g) compared to soaking prior to cooking (0.61mg/100g). Flavonoids are cytotoxic substances which interact with different enzymes through complexation (Mierziak *et al.*, 2014). The saponin content steadily declined from 3.36mg/100g in the raw yam flour to 2.92mg/100g in the sample which was soaked and then cooked. High levels of consumption of saponins in food intakes results in haemolysis of red blood cells due to saponin's ability to lyse erythrocytes (Podolak *et al.*, 2010).There were significant differences amongst the samples. The tannin content of the trifoliate yam flour samples reduced steadily from 0.32mg/100g in the raw yam flour to 0.28mg/100g in the sample cooked directly and then to 0.24mg/100g in the soaked and cooked yam flour. The values were generally lower than those obtained by Polycarp *et al*. (2012) (4.40-10.75 mg/100g). This dissimilarity may arise from varietal difference or variations in the method of analysis. Tannins are polyhydric phenols which are known to inhibit trypsin, chymotrypsin, amylase and lipase activities. Nonetheless, the amount of tannin may not provoke an astringent reaction in the mouth (Ohizua *et al.*, 2017). The phenol content in the flour samples had a decline from 1.83mg/100g in the raw sample to 1.16mg/100g in the sample cooked directly and 1.15mg/100g in the sample soaked and cooked. There was no significant difference between the flours obtained after treatment. Phenols are known to be toxic due to their hydrophobicity and generation of organic radicals and reactive oxygen species-precursors of cancer, haematoxicity and hepatotoxicity (Michalowicz & Duda, 2008)

Functional properties

Functional properties are those characteristics that govern the behavior of nutrients in food during processing, storage and preparation as they affect food quality and acceptability (Onwuka, 2005). They are parameters that determine a food materials application and end use (Ohizua, *et al.*, 2017). The result of functional properties of the bitter yam flour samples are presented in Table 3. The bulk density values (g/ml) increased, from the raw state (0.57) to the soaked (0.64) and cooked (0.68) form. The treatments increased the bulk density of the flour, though there was no significant difference amongst the samples. Bulk density is a measure of heaviness of a flour sample, and is generally affected by particle size. It is also important for determining packaging requirements, material handling and application in wet processing in the food industry (Kajihausa *et al*., 2014). This suggests that the soaked and cooked trifoliate yam flour would have more mass occupying the same volume than the other samples. The oil absorption capacity (g/g) of the samples ranged from 2.51 to 2.84g/g for the raw, and the soaked and cooked samples. The cooked (only) sample had an intermediate value of 2.64g/g. This implies that the soaked and cooked sample would retain more oil and hold flavor readily as well as improve the mouth feel of foods (Uzoukwu, *et al*., 2015b) than the other samples, as there were significant differences amongst the samples. On the basis of water absorption capacity, the directly cooked sample had a lower value (3.12g/g) than that soaked and cooked (3.34g/g). This is probably due to the double contact with water in the latter process and the efficiency of the drying process. High water absorption capacity is attributable to the loose structure of starch polymers while low values indicate the compactness of the structure (Adebowale, *et al*., 2012). This suggests the flours ability to retain some of the matrix of macromolecules to entrap large amounts of water. Flour samples with high WAC are desirable for use in the production of some confectionaries (Abdel, *et al.*, 2011). The samples were nonetheless, significantly different from each other. The foam capacity values (%) showed that the raw sample had the highest value (29.13%) followed by that soaked and cooked (26.13%) and the one cooked directly (24.22%) and cooked. Foam capacity is indicative of the ability of a flour sample to incorporate air by itself or in a mixture with other ingredients and to hold the aerated structure long enough so that it can be set by heat or other means. It is dependent on the presence of the flexible protein molecules which decrease the surface tension of water (Ohizua, *et al*, 2017).

CONCLUSION

Cooking, on one hand and soaking prior to cooking significantly affected the proximate, functional and anti-nutrient properties of trifoliate yam. Soaking (for 12hr) before cooking greatly lowered the quantity of anti-nutrients present in the tuber, and also enhanced the functional properties of the trifoliate yam tuber flour. It is advisable to subject trifoliate yam tuber samples (after peeling) to soaking and subsequently cooking.

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