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Effect of Soaking Prior to Oven-Drying on Some Nutrient and Anti-Nutrient Properties of Bitter Yam (*Dioscorea dumetorum*)

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Abstract

Soaking may improve the bitter yam properties processed by traditional method of drying and milling. The study investigated the effect of soaking prior to the traditional method of drying and milling on some nutrient and anti-nutrient properties of bitter yam flour. Four equal parts of cleaned, peeled and sliced bitter yam tubers were respectively soaked in clean water for 6, 12, 18 and 24 hours, dewatered, oven-dried at 50°C and milled, using standard procedures. The peak effect was recorded in the sample soaked for 24 hours which increased respectively by 13.12%, 29.41% and 0.81% for moisture, fat and carbohydrate, but decreased by 19.61%, 11.44%, 10.85%, 48.00% and 47.17% for crude fibre, ash, protein, alkaloid and tannin relative to control. Soaking, irrespective of time, prior to oven-drying (50°C) significantly improved the moisture and fat contents, but diminished the studied anti-nutrient and the other nutrient content of the bitter yam flour. The processing method did not favor the preservation of most of the studied properties. We recommend soaking prior to oven drying when the desired effect is overriding. Further studies, including sensory evaluation are warranted to address the possibility that the method may yield less bitter flour.

Keywords: *Dioscorea dumetorum;* Protein; Carbohydrate; Alkaloid; Tannin

Introduction

Yam (*Dioscorea spp*) is a food with economic and socio-cultural importance in many tropical countries [1]. Bitter yam (*Dioscorea dumetorum*) belongs to the genus *Dioscorea* and family *Dioscoreacae* [2]. Its other common name apart from bitter yam includes, African bitter yam, wild yellow yam, trifoliate (three-leaved) yam and cluster yam. Bitter yam is known as *'ji una'* or *'ji ona'* in Ojoto and many Igbo speaking area in the south-eastern Nigeria, where it is regarded as food for the adult who probably eat it for medicinal purpose. In the area, bitter yam serves as food of choice for the diabetic patients and as herb for the treatment of various ailments.

The inadequate food supply problem in sub-saharan African has heightened research effort aimed at finding alternative nutrient sources from available but less utilized plants [3] as well as processing methods that will enhance nutrient preservation and keeping/storage quality. Among other yam species, bitter yam is underutilized and understudied. It contributes to the household diet mainly in times of famine. The reason for the limited use of bitter yam, apart from the hard-to-cook defect [4], may be because of its unpalatable bitter taste, and high post harvest spoilage. The traditional method for processing bitter yam flour involving drying and milling appears not to address these possible reasons for bitter yam underutilization. Simple processing measures may stop further biologic activities that cause post harvest food spoilage, but may affect the food compositions [5]. Recently, Ezeocha et al. [6] reported that increased cooking duration improved the nutritional and phytochemical properties of the bitter yam, hence recommended method for processing bitter yam intended for human and animal nutrition. In a similar study [7], soaking prior to drying modified some functional properties of the bitter yam flour.

Nutrient and anti-nutrient properties could give insight into the possible taste and storage properties of food. This study therefore investigated the effect of soaking prior to oven-drying (50°C) on some nutrient and anti-nutrient properties of bitter yam flour. Anti-nutrients may reduce the nutrient utilization and/or food intake [8]. For instance, the anti-nutrient, tannin, by impairing iron availability [9,10], could limit the wider use of many plant foods. Thus, the result from this study apart from providing insight into the research area may provide basis for further studies aimed at improving the nutrient and anti-nutrient properties and possibly the taste and keeping quality of bitter yam flour.

Materials and Methods

Source and preparation of materials

Bitter yam tubers were purchased at Owerri relief market in Imo State, south-eastern Nigeria, from retail sellers who bought direct from local subsistence farmers. The equipment used including milling machine, weighing balance thermometer, shaker and centrifuge machine, were obtained from the Laboratory of Food Science and Technology Department, Federal Polytechnic Nekede Owerri, Imo State. All the chemicals used were of analytical grades.

Preparation of the bitter yam flour samples

Damaged tubers could result in loss of nutrients [11]. Therefore, wholesome bitter yam tubers were sorted out by handpicking, cleaned of dirt with tap water, peeled with a sharp table knife, sliced into cubes of 25 mm ± 2 mm thickness with a chipping machine and weighed. The chips were shared into five equal parts, based on weight. One part was not soaked in water and served as the control. Four parts

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were respectively soaked in clean water for 6, 12, 18 and 24 hours and drained. All (the five parts) were separately dried to a constant weight in a moisture extraction oven (Gallenkamp 1H-100) set at 50°C, cooled for 30 minutes and milled (in a laboratory mill, Thomas Wiley mill model ED-5) into flour. The separate samples flour was packed in labeled glassware covered with a stopper cork prior to analysis. The experiment was carried out at four soaking time (6, 12, 18 and 24 hours) at three replicates (4×3=12 replicates).

Proximate analysis

The protein content determination was by the method of Kjeidahl as described by James [12] while that of the fat content was by the continuous solvent extraction method as described by Pearson et al. [12,13]. The crude fibre content was determined by the method described by James [13]. The total ash content was determined by the furnace incineration gravimetric method [14]. The alkaloid content was determined by the alkaline precipitation method [15].

The tannin content was determined by the Follin-Dennis spectrophotometric method as described by Pearson [13]. The absorbance of the developed color was measured at 760 nm wavelength with the reagent blank set at zero, using GENWAY Model 6000 electronic spectrophotometer. The moisture content was determined by the method of James [12]. The carbohydrate content was determined by the Nitrogen free extractive (NFE) method described by Pearson [13].

Statistical analysis

Collected data were subjected to statistical Analysis of Variance (ANOVA) with the statistical package for social sciences (SPSS) for Windows version 16. The Bonferroni *post hoc* test was used to identify the means that differ significantly at $p<0.05$. Results were expressed as Mean ± standard deviation (SD).

Results

Results showed peak effect in the sample soaked for 24 hours which increased ($p<0.05$) respectively by 13.12% ($9.60^d \pm 0.12$% to $10.86^a \pm 0.01$%), 29.41% ($0.51^d \pm 0.02$% to $0.66^c \pm 0.03$%) and 0.81% ($77.90^c \pm 0.10$% to $78.53^a \pm 0.03$%) for moisture, fat and carbohydrate relative to control. The observation recorded for each parameter was significant ($p<0.05$) and time dependent (Table 1)

Soaking prior to oven drying caused a time dependent and significant decrease ($p<0.05$) in the crude fibre ($1.02^a \pm 0.03$% to $0.82^d \pm 0.04$%), ash ($3.76^a \pm 0.05$% to $3.33^d \pm 0.05$%) and protein ($6.73^a \pm 0.05$% to $6.00^e \pm 0.26$%) content of the bitter yam flour. This represents a decrease by 19.61%, 11.44% and 10.85% respectively in the sample soaked for 24 hours relative to control (Table 2).

Soaking, prior to oven drying, caused a time dependent decrease ($p<0.05$) in the anti-nutrients: alkaloid ($1.75^a \pm 0.00$% to $0.91^d \pm 0.00$%) and tannin ($22.12^a \pm 0.00$% to $1.12^d \pm 0.01$%) content of the bitter yam flour. This represents a decrease by 48.00% and 47.17% respectively in the sample soaked for 24 hours relative to control (Table 3 and Figure 1).

Discussion

In this study, a significant ($p<0.05$) and time dependent increase in the moisture content was recorded for the bitter yam flour obtained after soaking. The peak effect was recorded in the sample soaked for 24 hours which increased by 13.12% relative to control. This may indicate

Soaking time (hrs)	Moisture content (%)	Relative increase of moisture content (%)	Crude fat (%)	Relative increase of crude fat (%)	Crude carbohydrate (%)	Relative increase of crude carbohydrate (%)
0	$9.60^d \pm 0.12$		$0.51^d \pm 0.02$		$77.90^c \pm 0.10$	
6	$10.76^c \pm 0.02$	12.08	$0.58^a \pm 0.02$	13.73	$77.94^c \pm 0.14$	0.05
12	$10.79^c \pm 0.01$	12.40	$0.61^b \pm 0.05$	19.61	$78.07^d \pm 0.04$	0.23
18	$10.81^b \pm 0.01$	12.60	$0.65^c \pm 0.01$	27.45	$78.27^b \pm 0.30$	0.48
24	$10.86^a \pm 0.01$	13.12	$0.66^c \pm 0.03$	29.41	$78.53^a \pm 0.03$	0.81

Values are mean ± standard deviation of triplicate determinations. Values on the same column with different superscripts means that the difference is statistically significant ($p<0.05$)

Table 1: Moisture, fat and carbohydrate content of soaked bitter (trifoliate) yam flour.

Soaking time (hrs)	Protein content (%)	Relative decrease of protein content (%)	Crude ash (%)	Relative decrease of crude ash content (%)	Crude fibre (%)	Relative decrease of crude fibre content (%)
0	$6.73^a \pm 0.05$		$3.76^a \pm 0.05$		$1.02^a \pm 0.03$	
6	$6.37^b \pm 0.21$	5.35	$3.42^b \pm 0.02$	9.04	$0.95^b \pm 0.01$	6.86
12	$6.23^c \pm 0.00$	7.43	$3.41^b \pm 0.01$	9.31	$0.94^b \pm 0.05$	7.84
18	$6.21^d \pm 0.01$	7.73	$3.36^c \pm 0.05$	10.64	$0.91^c \pm 0.04$	10.78
24	$6.00^e \pm 0.26$	10.85	$3.33^d \pm 0.05$	11.44	$0.82^d \pm 0.04$	19.61

Values are mean ± standard deviation of triplicate determinations. Values on the same column with different superscripts means that the difference is statistically significant ($p<0.05$)

Table 2: Protein, ash and fibre content of soaked bitter (trifoliate) yam flour.

Soaking time (hrs)	Alkaloids content (%)	Relative decrease of alkaloids content (%)	Tannins (%)	Relative decrease of tannins content (%)
0	$1.75^a \pm 0.00$		$2.12^a \pm 0.00$	
6	$1.75^a \pm 0.01$	0.00	$2.12^a \pm 0.01$	0.00
12	$1.41^b \pm 0.01$	19.43	$1.83^b \pm 0.02$	13.68
18	$1.28^c \pm 0.01$	26.86	$1.63^c \pm 0.01$	23.11
24	$0.91^d \pm 0.00$	48.00	$1.12^d \pm 0.01$	47.17

Values are mean ± standard deviation of triplicate determinations. Values on the same column with different superscripts means that the difference is statistically significant ($p<0.05$)

Table 3: Alkaloids and tannins content of soaked bitter (trifoliate) yam flour.

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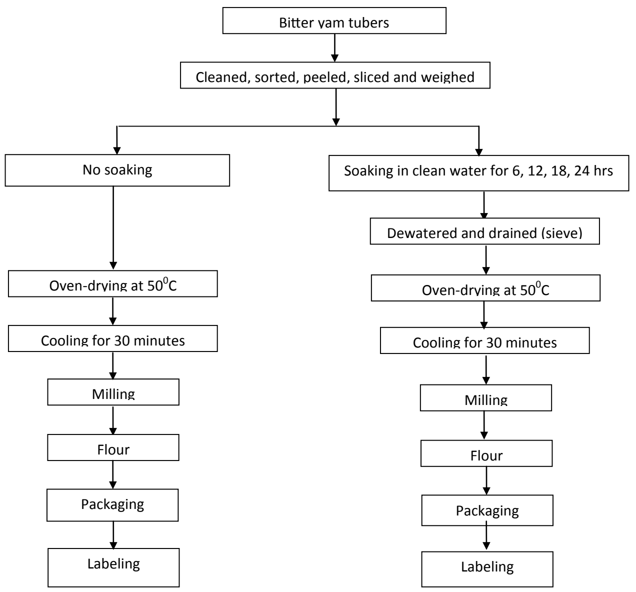

Figure 1: Schematic diagram for the control and soaked bitter yam flour.

poor stability [16,17]. Reduced moisture content enhances food stability and preservation, by inhibiting microbial growth/attack [18,19] and by diminishing acid value and free fatty acids [20]. Water absorbed during soaking may account for the moisture gain, and oven drying at 50 °C to constant weight probably did not reverse the moisture gain. Thus, soaking prior to oven drying at 50°C, by increasing the moisture content, may not favor the keeping quality of the bitter yam flour.

Crude fat increased from $0.51^{d} \pm 0.02\%$ to $0.66^{c} \pm 0.03\%$, representing an increase by 29.41% in the sample soaked for 24 hours relative to control. This suggests enhanced fat formation and (fat) preservation during soaking. Ejikeme et al. [20] reported that increased moisture content (as observed in this study) resulted in increased free fatty acids. High fat could diminish the storage life of the flour due to increased chance for rancid flavor development. Thus, this result implies higher fat content and energy potential, but higher possibility of spoilage of the bitter yam flour obtained by soaking prior to oven drying.

Ash content may be associated with the amount of mineral present in a sample; hence the decreased crude ash content by 11.44% noted in the present study suggests a reduction in mineral contents of the bitter yam flour. Part of the mineral content may have leached into the soaking water resulting in the observed decrease. The result (3.76% to 3.33 %) compares with that for processed brown pigeon pea (4.85% to 3.41%) reported by Uzoechina [21].

Crude fibre decreased ($p<0.05$) by 19.61% in the sample soaked for 24 hours as against the control. This indicates poor crude fibre preservation and poor digestibility of bitter yam flour obtained by soaking prior to oven drying. The value range ($1.02^{a} \pm 0.03\%$ to $0.82^{d} \pm 0.04\%$) falls below the range reported earlier [22,23] in processed foods. Thus, soaking prior to oven drying at 50°C may further diminish the crude fibre content, and the acceptability of bitter yam flour as crude fibre source.

The significant reduction in protein contents observed in this study may be attributed to protein denaturation by the heat generated during the soaking process. Further, the soaking water (and the heat thus generated) may favor the insoluble complex formation by tannin and protein [24] resulting in the reduction of protein and tannin as observed in this study.

The carbohydrate content range ($77.90^{c} \pm 0.10\%$ to $78.53^{a} \pm 0.03\%$) of the bitter yam flour samples compares with that of Ezeocha *et al.* [6]. The crude carbohydrate content increased in a time dependent manner, suggesting improved carbohydrate content. This may further imply that bitter yam flour obtained by soaking prior to oven drying (50°C) could serve as a good dietary energy source. During soaking process, carbohydrates may absorb water that as universal solvent may unbind carbohydrates from their complexes with non-nutritive components of the bitter yam flour leading to the increase.

Osagie [8] reported that simple soaking could reduce the content of anti-nutrients in the bitter yam. In the present work, the anti-nutritional factors studied decreased ($p<0.05$), suggesting their possible inactivation in the bitter yam flour due to soaking. Anti-nutritional factors are heat labile [25], thus possible heat generated by the soaking process could have inactivated the anti-nutritional factors resulting in their decrease in this study. In particular, the decrease in tannin and alkaloid may be enhanced by their solubility in water [26] and their leaching into the soaking water [27]. This could be desirable or undesirable. Alkaloid imparts a bitter taste to most foods. However, alkaloid and tannin have pharmacological and medicinal potentials that are desirable besides their toxic and anti-nutritive effects that are undesirable [28]. Tannins are constituents of several drugs because of their astringent property and dietary tannins can contribute to improved animal health [29]. The present study demonstrated a time dependent reduction in the studied anti-nutrient factors, suggesting that complete elimination of these anti-nutrients in bitter yam flour may be achieved by increasing the soaking time.

Generally, the (studied) content of the raw bitter yam flour compared favorably with that of Ezeocha et al. [6]. However, soaking prior to oven drying at 50°C as a processing method seems not to favor the preservation of most of the studied nutrients and anti-nutrients, hence is recommended when the desired effect is overriding. The effect on the parameters was time dependent, suggesting possible enhancement with increasing processing time. Thus, soaking, irrespective of time, prior to oven-drying (50°C) significantly improved the moisture and fat contents, but diminished the anti-nutrient and the other nutrient content of the bitter yam flour. The implications of the study as discussed which further suggest the possibility that soaking prior to oven-drying (50°C) may yield bitter yam flour with a less bitter, short-term keeping dietary fat-based energy are noteworthy hence warrant further investigations, including sensory evaluation.

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