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The effect of boiling and soaking time on the chemical and functional properties of wild bitter yam

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Abstract
The effect of boiling and soaking time on the chemical composition and functional properties of wild bitter yam (WBY) was investigated. Wild bitter yam samples was peeled, washed and randomly divided into 4 lots. The first lot was the un-boiled and un-soaked samples which served as control while the remaining 3 lots were cooked in boiling water for varying length of time; 20, 30 and 40 minutes, respectively. The boiled lots were allowed to cool, shredded into three well labeled bowls. The strips from each boiled lot were washed 4 times in water tuber ratio of 2:1, respectively and each lot was split into 2 sub-lots. The sub-lots were soaked in water at water tuber ratio of 2:1 for 14 and 16 hours, respectively, washed 5 times, drained and sun-dried. The dried strips were milled and packaged in an airtight plastic container to give a total of 6 WBY samples. The samples were evaluated for chemical composition and functional properties. The proximate composition of the WBY samples varied from 8.57–12.84% for moisture, protein 7.00–8.93%, fiber 2.17–2.36%, fat 1.10–1.17%, ash 1.68–1.93% and carbohydrate 75.05–77.03%. The phytochemcial contents ranged from 0.41–0.48% for alkaloid, flavonoid 0.23–0.30%, tannin 0.14–0.18%, saponin 0.18–0.35%, phenol 0.52–0.61%, oxalate 0.21–0.37% and dioscorine 326.87–304.35mg/100g. There was a general decrease in the phytochemcial contents of the yam samples with increasing boiling and soaking time The functional properties of WBY samples varied from 0.43–0.50g/cm^3 for bulk density, water absorption capacity 5.05–7.10g/g and oil absorption capacity 6.55–7.83g/g. Boiling WBY for 30 minutes and soaking for 14 hours was able to reduce the toxic dioscorine to safe levels while still retaining the nutrients.

Keywords: wild bitter yam, boiling, soaking, dioscorine

1. Introduction

In Nigeria there are many foodstuffs which makeup parts of the traditional food system but their economic and nutritional values have not been well explored as in the case of *Dioscorea dumetorum* especially the wild variety that is eaten only in times of food scarcity [4]. In Nigeria, farmers rarely establish a whole farm of bitter yam, they are commonly grown in hedgerows around the farm as a deterrent to human and animal invaders while others purposely grow bitter yam at sparse points on a yam plot as insurance against low yields of the desired varieties [6]. Bitter yam (*Dioscorea dumetorum*) originated in tropical Africa and occurs in both wild and domesticated forms [1]. The wild variety of bitter yam on visual inspection has more spines (thorns) generally in the aerial part than in the cultivated variety particularly near the stem base [44]. In Nigeria, the wild bitter yam is known as *Iwu* or *Ighu*; *Gudugudu* or *Esureko* and *Doyanbiri* or *Rogonbiri* in the Igbo, Yoruba and Hausa languages, respectively [43].

The most predominant phytochemicals in wild yam are the dioscorine alkaloid and diosgenin saponin, although dioscorine and diosgenin are naturally considered toxic, such toxicity is reduced to minimal levels by washing, boiling and cooking [12]. Alkaloid poisoning is reported to cause general paralysis of the central nervous system, which can also result in seizures and convulsion [29]. The lethal dose (LD_{50}) of dioscorine has been reported to be 600 mg/100g [18]. The edible variety of bitter yam is consumed as food mainly by boiling or roasting the unpeeled fresh tubers to softness and is then eaten with vegetable oil (mostly palm oil) or a local sauce and indigenes of Akwa Ibom State use specifically sweet cultivars of edible variety of bitter yam in the preparation of yam soup [43]. Homestead processing of wild bitter yam is carried out in some communities in Enugu, Imo, Abia, Ebonyi and Anambra [43]. Traditional detoxifying unit operations are used to convert the poisonous bitter tubers of the wild variety into storable food materials [43] used in preparing a kind of delicacy similar to African salad (*Abacha*) that is processed from boiled cassava tubers. Traditionally the wild varieties of bitter yam are detoxified by slicing, soaking (1-3 days), boiling (15-20 minutes) and washing sometimes with addition of salt or the sliced tubers are tied in a jute sack and left in a running water for 3 days to reduce toxic and bitter compounds that are believed to be injurious to health [1, 43]. Apart from its food uses, wild bitter yam is also highly utilized in traditional medicine for treatment of some illness such as diabetes mellitus, schistosomiasis, jaundice, malaria, as a tropical anesthetic and also applied in suppressing abscesses [14, 28 and 41].

Food poisoning arising from plant secondary metabolites otherwise known as anti- nutritional factors other than cyanogenic glycosides has not been properly addressed in Nigeria and indeed in most parts of the developing countries that depend on or feed mostly on vegetable-based diets [40]. Soetan and Oyewole (2009) [40] had reported that different processing methods like soaking and cooking can reduce toxic effects of most anti-nutritional factors present in the plant foods. Unfortunately, very little information is available on the effect of processing on the chemical composition of wild bitter yam. This study was therefore designed to evaluate the effect of different boiling and soaking time on the chemical composition and functional properties of wild bitter yam.

2. Materials and Methods

2.1 Sources of raw materials

Freshly harvested wild bitter yam was obtained from a bush in Umuadogwa, Umuida, Enugu-ezike, Enugu State Nigeria. The plant was identified and authenticated in the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Nigeria.

2.2. Preparation of wild bitter yam flour

Traditionally in Ezeagu community of Enugu State, Nigeria wild bitter yam (WBY) is cooked in boiling water for 20 minutes and soaked for 14 hours during processing. The method of sample preparation was modified from traditional method utilized in Ezeagu. Wild bitter yam (WBY) was sorted to obtain wholesome tubers and washed to remove adhering soil. The samples were then manually peeled and washed in water tuber ratio of 2:1. The washed samples were randomly divided into 4 lots. The first lot was the un-boiled and un-soaked samples which served as control while the remaining 3 lots were cooked in boiling water for varying length of time- 20, 30 and 40 minutes, respectively. The boiled tubers were allowed to cool, shredded to strips using a locally fabricated shredder separately into three well labeled bowls. The WBY strips from each boiled lot were washed 4 times in water tuber ratio of 2:1, respectively and each lot was split into 2 sub-lots. The sub-lots were soaked in water at water tuber ratio of 2:1 for 14 and 16 hours respectively, washed again 5 times in the same water tuber ratio, drained and sun-dried (Temp-26.67°C and RH- 50% for 10 hours). The dried strips were milled using an electric miller (Master Chef Blender, MC-B115 made in China) and then packaged in a well labeled airtight plastic container at room temperature (25°C ±1).

2.3 Determination of proximate composition

Proximate composition was carried out according to the Official Methods of Analysis (AOAC, 2010) [5].

2.4 Determination of phytochemcial composition

The alkaloid, saponin and flavonoid contents were determined using the method described by Harborne (1973) [15]. The phenol content was determined using the Folin-Ciocalteu colorimetric method described by Pearson (1976) [36] and tannin content by the Follins-Dennis spectrophotometric method as described by Pearson (1976) [36]. The method of analysis described by Day and Underwood (1986) [9] was used to determine oxalate content. Dioscorine was extracted from the yam samples using the method described by Kumoro and Hartati (2015) [20] and quantified according to Sasiwatpaisit *et al*. (2014) [38].

2.5 Determination of functional properties

The oil absorption capacity (OAC) and water absorption capacity (WAC) of the samples were determined according to the method described by Lin *et al*. (1974) [23]. Bulk density was determined by the method described by Nwanekezi *et al*. (2001) [25].

2.6 Experimental design and Statistical analysis

Analyses were done in triplicate. The experiment was conducted in factorial form using completely randomized design. The first factor was 3 boiling time (20, 30 and 40 minutes) and the second factor was 2 soaking time (14 and 16 hours). Data were analyzed using Minitab 17 statistical software. Mean separation was done using Duncan's multiple ranges test and statistical significance was accepted at $p<0.05$.

3. Results

The effect of boiling and soaking time on the proximate composition of wild bitter yam is presented on Table 1. The moisture content of the boiled and soaked WBY ranged from 8.57 to 12.86% for WBY boiled for 20 minutes and soaked for 14 hours and WBY boiled for 40 minutes and soaked for 16 hours, respectively. Wild bitter yam boiled for 40 minutes and soaked for 16 hours had the least protein value (7.00%) while WBY boiled for 20 minutes and soaked for 14 hours had the highest protein content (8.93%). The fibre contents varied from 2.17 to 2.36% for WBY boiled for 40 minutes and soaked for 14 and 16 hours and WBY boiled for 20 minutes and soaked for 14 hours, respectively. The ash contents ranged from 1.68% in WBY boiled for 40 minutes and soaked for 16 hours to 1.93% in WBY boiled for 20 minutes and soaked for 14 hours. Wild bitter yam boiled for 40 minutes and soaked for 16 hours had the least fat content (1.10%) while yam samples boiled for 20 minutes and soaked for 14 hours had the highest fat content (1.17%). The carbohydrate content varied from 75.05 to 77.56% in WBY boiled for 40 minutes and soaked for 14 hours and WBY boiled for 20 minutes and soaked for 16 hours, respectively.

Table 1: Effect of boiling and soaking time on the proximate composition of wild bitter yam

Boiling time (minutes)	Soaking time (hours)	Moisture (%)	Crude protein (%)	Crude fiber (%)	Ash (%)	Fat (%)	Carbohydrate (%)
0	0	7.00±0.03^{a}	9.19±0.13^{a}	2.68±0.00^{a}	2.67±0.00^{a}	1.28±0.03^{a}	77.18±0.04^{f}
20	14	8.57±0.01^{a}	8.93±0.00^{b}	2.36±0.00^{b}	1.93±0.04^{b}	1.17±0.01^{b}	77.03±0.06^{d}
20	16	8.58±0.08^{a}	8.49±0.13^{c}	2.32±0.03^{bc}	1.92±0.03^{b}	1.13±0.01^{c}	77.56±0.11^{c}
30	14	10.47±0.01^{a}	8.40±0.00^{c}	2.30±0.03^{c}	1.91±0.01^{b}	1.11±0.01^{c}	75.81±0.01^{e}
30	16	10.43±0.01^{a}	8.40±0.00^{c}	2.27±0.01^{c}	1.88±0.03^{b}	1.12±0.00^{c}	75.90±0.03^{e}
40	14	12.84±5.69^{a}	7.09±0.13^{d}	2.17±0.01^{d}	1.74±0.03^{c}	1.11±0.01^{c}	75.05±0.10^{b}
40	16	12.86±0.03^{a}	7.00±0.00^{d}	2.17±0.01^{d}	1.68±0.00^{c}	1.10±0.00^{c}	75.19±0.04^{a}

Values are means of triplicate determinations ± SD. Means with different superscript in the same column are significantly ($p < 0.05$) different.

Table 2 shows the effect of boiling and soaking time on the phytochemcial content of wild bitter yam. The alkaloid content of WBY samples ranged from 0.41 to 0.48% for WBY boiled for 40 minutes and soaked for 16 hours and WBY soaked for 20 minutes and boiled for 14 hours, respectively. The flavonoid content of the samples varied from 0.21% in WBY boiled for 30 minutes and soaked for 16 hours to 0.30% in WBY soaked for 20 minutes and boiled for 14 hours. The tannin contents ranged from 0.14 to 0.18% for WBY boiled for 30 minutes and soaked for 16 hours, boiled for 40 minutes and soaked for 14 and 16 hours and WBY soaked for 20 minutes and boiled for 14 hours, respectively. The saponin content varied from 0.18 to 0.35% with WBY boiled for 40 minutes and soaked for 16 hours and WBY soaked for 20 minutes and boiled for 14 hours, respectively. The phenol contents ranged from 0.52% in WBY boiled for 40 minutes and soaked for 14 and 16 hours, respectively to 0.61% in WBY soaked for 20 minutes and boiled for 14 hours, respectively. The oxalate contents varied from 0.21 to 0.37% for WBY boiled for 40 minutes and soaked for 16 hours and WBY soaked for 20 minutes and boiled for 14 hours, respectively. The dioscorine content ranged from 304.35mg/100g in WBY boiled for 40 minutes and soaked for 16 hours to 326.87mg/100g with WBY boiled for 20 minutes and soaked for 14 hours.

Table 2: Effect of boiling and soaking time on the phytochemcial content of wild bitter yam

Boiling time (minutes)	Soaking time (hours)	Alkaloid (%)	Flavonoid (%)	Tannin (%)	Saponin (%)	Phenol (%)	Oxalate (%)	Dioscorine (mg/100g)
0	0	0.95±0.01^{a}	0.60±0.03^{a}	0.28±0.03^{a}	0.64±0.03^{a}	1.24±0.01^{a}	0.59±0.04^{a}	684.01±1.10^{a}
20	14	0.48±0.03^{b}	0.30±0.03^{b}	0.18±0.00^{b}	0.35±0.10^{b}	0.61±0.04^{b}	0.37±0.01^{b}	326.87±1.10^{b}
20	16	0.45±0.01^{c}	0.27±0.01^{bc}	0.16±0.01^{bc}	0.24±0.00^{c}	0.55±0.00^{c}	0.30±0.03^{cd}	323.76±1.10^{b}
30	14	0.44±0.00^{c}	0.22±0.00^{c}	0.15±0.00^{bc}	0.22±0.00^{c}	0.65±0.02^{b}	0.25±0.04^{d}	317.56±1.10^{c}
30	16	0.44±0.03^{c}	0.21±0.04^{c}	0.14±0.03^{c}	0.23±0.00^{c}	0.54±0.02^{c}	0.28±0.04^{d}	313.66±0.00^{d}
40	14	0.42±0.00^{c} 0.22^{c}±0.03	0.22±0.03^{c}	0.14±0.00^{c}	0.22±0.00^{c} 0	0.52±0.00^{c}	0.22±0.01^{e}	309.01±2.20^{e}
40	16	0.41±0.01^{c}	0.23±0.04^{c}	0.14±0.00^{c}	0.18±0.00^{cd}	0.52±0.02^{c}	0.21±0.00^{e}	304.35±0.00^{f}

Values are means of triplicate determinations ± SD. Means with different superscript in the same column are significantly ($p < 0.05$) different.

Table 3 shows the effect of boiling and soaking time on bulk densities, water (WAC) and oil absorption capacities (OAC) of the wild bitter yam samples. The bulk densities of the boiled and soaked samples ranged from 0.43g/cm^3 in WBY boiled for 40 minutes and soaked for 14 hours to 0.50g/cm^3 in WBY boiled for 30 minutes and soaked for 16 hours and those boiled for 40 minutes and soaked for 16 hours. The WAC varied from 5.05 to 7.10g/g for WBY boiled for 20 minutes and soaked for 14 hours and samples boiled for 30 minutes and soaked for 16 hours, respectively. The OAC ranged from 6.55 to 7.49g/g in WBY boiled for 30 minutes and soaked for 16 hours and WBY boiled for 40 minutes and soaked for 16 hours, respectively.

Table 3: Effect of boiling and soaking time on the functional properties of wild bitter

Boiling time (minutes)	Soaking time (hours)	Bulk density (g/cm^3)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)
0	0	0.30±0.01^{d}	4.56±0.07^{f}	6.08±0.00^{d}
20	14	0.49±0.00^{a}	5.05±0.07^{e}	6.98±0.06^{b}
20	16	0.49±0.01^{a}	6.85±0.07^{b}	7.02±0.00^{b}
30	14	0.44±0.00^{c}	6.85±0.07^{b}	7.35±0.20^{a}
30	16	0.50±0.00^{b}	7.10±0.14^{a}	6.55±0.00^{c}
40	14	0.43±0.00^{c}	5.55±0.07^{d}	7.44±0.07^{a}
40	16	0.50±0.00^{b}	5.95±0.07^{c}	7.49±0.00^{a}

Values are means of triplicate determinations ± SD. Means with different superscript in the same column are significantly ($p < 0.05$) different.

4. Discussion

The proximate composition of wild bitter yam showed that all the analyzed components were significantly higher ($p<0.05$) in the raw tubers. The moisture content increased by 83.7% when boiled for 40 minutes and soaked for 16 hours relative to control sample. The increase observed may be due to moisture absorption during boiling and soaking. Owuamanam *et al*. (2013) [35] reported higher amount of moisture (13.25%) for bitter yam flours obtained by boiling for 30 minutes in trona solution. Water absorbed during soaking may also account for the moisture gain [11]. All the WBY samples had moisture content below 13% which is the standard for dry food samples as described by Prinyawiwatkul *et al*. (1997) [37]. An Increase in moisture content as observed during processing will result in poor storability of the resultant yam flour. The protein content decreased by 23.8% when boiled for 40 minutes and soaked for 16 hours relative to control sample. The decreasing trend of crude protein observed might suggest that boiling led to leaching out of soluble proteins and the intensity of leaching increased with the duration of boiling [35]. Uzoukwu *et al*. (2015) [45] also reported lower values of protein in normal (2.1%) and late harvest (3.0 %) trifoliate yam after boiling with their peels for 1 hour. The crude fiber content decreased by 19.1% when boiled for 40 minutes and soaked for 16 hours relative to un-boiled and un-soaked WBY. Soluble hemicelluloses may have been lost into the boiling water and may have accounted for the reduction in fiber observed. Egbuonu and Nzewi (2016) [11] reported lower values of fiber (1.02%) in edible bitter yam while Ogbuagu (2008) [26] reported 1.05% of fiber in wild bitter yam after boiling and steeping in slow running water for 24 hours. Boiling and soaking of WBY diminished the crude fibre content and the acceptability of bitter yam flour as crude fibre source. Wild bitter yam boiled for 40 minutes and soaked for 16 hours lost 37.1% relative to un-boiled and un-soaked WBY. The decrease in ash content observed may be due to leaching of some mineral compounds into the boiling and soaking water. The observed decrease in ash content with boiling and soaking implies that the potential ability of the tuber to supply essential minerals has been reduced. Adejumo *et al*. (2013) [2] reported that soaking time has no effect on the ash content of yam. Boiling of wild bitter yam for 40 minutes and soaking for 16 hours resulted in 14.1%

decrease in the crude fat content relative to control sample. Yams generally contain low levels of fat [17]. The reduction of fat observed may enhance the storage life of the flour due to reduced chance for rancidity but may reduce the energy value of the resultant flour [12]. The carbohydrate content of the WBY samples decreased by 2.58% when boiled for 40 minutes and soaked for 16 hours relative to the control sample. The carbohydrate contents of WBY samples observed in the present study agrees with the range of values (60 to 90%) reported by Ogbuagu (2008) [26] as the carbohydrate makeup of the dry matter of most root and tuber crops.

The phytochemcial content of WBY samples decreased in a time dependent manner with boiling and soaking suggesting leaching into the boiling or soaking medium. The alkaloid, flavonoid, saponin and tannin contents remained fairly constant until when boiled 30 minutes and soaked for 14 hours. The alkaloid content of boiled and soaked WBY decreased from by 56.84% when boiled for boiled for 40 minutes and soaked for 16 hours relative to the control sample. Most alkaloids are known for their pharmacological effects rather than their toxicity. However when alkaloids occur in high levels in foods, they cause gastro-intestinal upset and neurological disorders [29]. The availability of alkaloids in the tubers of Dioscorea spp. indicates that yam tubers cannot be eaten raw [27]. The decrease in alkaloid observed may have been enhanced by their solubility in water [31] which probably facilitated the leaching of the compound into the soaking water [13]. The decrease in alkaloid observed with boiling and soaking increases the consumption safety of WBY. Wild bitter yam boiled for 40 minutes and soaking for 16 hours resulted in a 61.7% decrease in flavonoid relative to un-boiled and un-soaked WBY. Ezeocha *et al*. (2012) [13] reported flavonoid content of 0.00051% with boiling of edible bitter yam for 30 minutes and this was lower than the values obtained. Flavonoids exhibit a wide spectrum of pharmacological properties including anti-oxidative, anti-allergic, anti-inflammatory and anti-diabetic [38]. The tannin content decreased by 50% when boiled for 40 minutes and soaked for 16 hours, respectively relative to un-boiled and un-soaked WBY. Egbuonu and Nzewi (2016) [11] reported higher tannin content (0.80%) when edible bitter yam was blanched for 15 minutes while Ezeocha *et al*. (2012) [13] reported lower tannin content (0.00028%) when edible bitter yam was boiled for 30 minutes. The significant reduction in tannin content suggests reduced toxic potential hence improved safety of wild bitter yam flour processed by boiling and soaking. The saponin content of boiled and soaked WBY decreased by 71.9% when boiled for 40 minutes and soaked for 16 hours relative to the control sample. Soaking has been reported to be effective in reducing the levels of tannins [32]. Ezeocha *et al*. (2012) [13]) reported 0.00292% saponin when edible bitter yam was boiled for 30 minutes while Okwu and Ndu (2006) [30] reported lower saponin (0.01478%) in raw edible bitter yam. Saponin has a natural tendency to ward off microbes making them good candidate for treating fungal and yeast infections [39]. The reduction in the saponin content observed favours the absorption of zinc and iron and their consumption safety. The phenol content of WBY boiled for 40 minutes and soaked for 16 hours decreased by 64.4% relative to un-boiled and un-soaked WBY. Ezeocha *et al*. (2012) [13] reported 0.00116% phenol content with boiling of edible bitter yam for 30 minutes. The reductions in phenol have been attributed to leaching of the compounds into the cooking water during prolonged exposure to water and heat [8]. At low levels as observed with boiling and soaking of WBY, phenol acts as antioxidants in diet. The oxalate content of WBY boiled for 40 minutes and soaked for 16 hours decreased by 58.1% relative to the control sample. Huang *et al*. (2007) [16] also reported that cooking reduced oxalate content by 56.70%. Oxalic acid and oxalate occur naturally in plants but they have little or no useful effect on human health as high levels in diets lead to irritation of the tissues, the digestion system, particularly the stomach and kidney [22]. Ingestion of higher amount of oxalate (2g at a time) is thought to be fatal dose for humans [22]. Noonan and Savage (1999) [24] had earlier reported that soaking decreases oxalate levels in food by leaching. The reduction in oxalate observed in this study increases the consumption safety of WBY. Wild bitter yam boiled for 40 minutes and soaked for 14 hours lost 55.5% dioscorine relative to un-boiled and un-soaked WBY. Abiodun *et al*. (2013) [1] reported that the predominant alkaloids in trifoliate yam flours were dioscorine and dihydrodioscorine. Dioscorine a hypoglycaemic principle has been isolated from wild bitter yam tubers [18] and has been shown to be as effective as tolbutamide in lowering blood sugar levels in both normal and alloxan-induced diabetic rabbits [19]. Iwu *et al*. (1990a) [18] reported that 200mg/100g of dioscorine reduced the blood sugar level of normglycaemic rabbit and alloxan-diabetic rabbit. The lethal dose (LD_{50}) of dioscorine has been reported to be 600mg/100g [18]. Boiling and soaking minimized the levels of dioscorine in WBY to safe levels therefore increasing its consumption safety.

There were significant ($p<0.05$) increase in the functional properties with boiling and soaking of WBY. The peak bulk density was observed when WBY was boiled for 30 minutes and soaked for 16 hours with a 66.7% increase relative to the control sample. Bulk density is reported to be a function of particle size; particle size is inversely proportional to bulk density [46]. Low Bulk density of flours are good physical attributes when determining transportation and storability since the products could be easily transported and distributed to required locations [3]. The increasing bulk density observed suggest the suitability of WBY flour in food preparation but not in the formulation of complimentary food. The peak water absorption capacity was observed when WBY was boiled for 30 minutes and soaked for 16 hours with a 55.7% increase relative to the control sample. Water absorption capacity measures the volume occupied by the starch after swelling in excess water and indicates the integrity of starch in aqueous dispersion [21] and is desirable in food systems to improve yield and consistency and give body to the food [34]. The increasing WAC observed to improve yield and consistency Owuamanam *et al*. (2013) [36] also reported a significant increase in WAC of bitter yam processed by steeping and boiling in varying concentration of trona solution. The peak oil absorption capacity was observed when WBY was boiled for 30 minutes and soaked for 14 hours with a 20.9% increase relative to the control sample. Oil absorption capacity is the ability of proteins of flours to bind with oil and is useful in food system to facilitate enhancement in flavour and mouth-feel [7] so WBY obtained by boiling and soaking will have good flavour retention potential. Generally, the results imply that wild bitter yam flour obtained in this study may serve as low fat energy food source, with possibly diminished stability/keeping quality, medicinal potential, toxicity and bitter taste.

5. Conclusion

A time dependent decrease was observed in protein, fat, energy, fibre and carbohydrate contents of the WBY samples with their boiling and soaking. The alkaloid, flavonoid, tannin, phenol, oxalate, dioscorine and saponin contents of WBY decrease in a time dependent manner with boiling and soaking. The functional properties determined increased with boiling and soaking of WBY until when boiled beyond 30 minutes. Although the observed effect on phytochemcial contents may improve taste and consumption safety, the process reduced many important nutrients and may diminish the keeping quality of the resultant flour. Wild bitter yam can be boiled for 30 minutes and soaked for 16 hours as this method of processing causes minimal loss of protein, fiber, ash, fat and carbohydrate contents and reduced the toxic phytochemicals to safe levels.

6. References

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