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Full Length Research Paper

The impact of cooking on the proximate composition and anti-nutritional factors of water yam (*Dioscorea alata*)

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Raw and boiled water yam tubers (*Dioscorea alata*) were analyzed for proximate contents such as ash, crude protein, carbohydrate, crude fibre, crude lipid, energy and anti-nutrients using standard procedures and methods. The crude protein contents (10.27%), ash (2.93%) and lipid (0.15%) were significantly ($p<0.05$) lowered in the boiled tubers while the carbohydrate (76.57%) significantly ($p<0.05$) increased in the boiled tubers. The antinutrients; alkaloids (2.77%), saponins (2.71%), flavonoids (1.38%) and tannins (0.21%) significantly ($p<0.05$) reduced in the boiled tubers. It was concluded that boiling had both positive and negative effect on water yam. A cooking time of between 30 and 60 min at 100°C was recommended for *D. alata*.

Key words: Water yam, boiling, proximate content, anti-nutrients.

INTRODUCTION

Yam is one of the staple foods in Nigeria and other tropical African countries. The yams are members of the genus *Dioscorea* in the section, Enantiophyllum. *Dioscorea* is the largest genus of the family Dioscoreaceae, containing between three and six hundred species (Vernier et al., 1998). Yam is grown and cultivated for its energy-rich tuber. Only a few species of yams are cultivated as food crops. The most important species of *Dioscorea* include *D. rotundata, D. alata, D. cayenensis, D. dumetorum, D. esculenta and D. bulbifera. Dioscorea alata*, called "water yam", "winged yam" and "purple yam", is the species most widely spread throughout the world and in Africa is second only to white yam in popularity (Mignouna et al., 2004). Yam is an excellent source of starch, which provides calorific energy (Coursey, 1973). It also provides protein three times more superior than the one of cassava and sweet potato (Bourret-Cortedellas, 1973). Yams are consumed as staple food. Apart from food, yams are also sources of pharmaceutical compounds like saponins and sapogenins, which are precursors of cortisone (a hormone from the adrenal gland used medically in the treatment of arthritis and some allergies) (Higdon et al., 2001). Water yam (*Dioscorea alata*) is the most economically important yam species which serve as a staple food for millions of people in tropical and sub-tropical countries (Coursey, 1967; Hahn, 1995). *D. alata* is a crop with potential for increased consumer demand due to its low sugar content necessary for diabetic patients (Udensi *et al*., 2010). Yams generally have high moisture content; the dry matter is composed mainly of starch, vitamins, sugars and minerals. Nutrient content varies with species and cooking procedures. Yams may also contain small quantities of polyphenolic compounds (e.g. tannins), alkaloids (e.g. dioscorine), steroid derivatives (e.g. diosgenin), calcium oxalate crystals and phytic acid. *D. alata* cultivars possess a higher content of protein, vitamin C and low lipids than *D.* cayenensis, *D. escunlenta*, *D. rotundata* and *D. trifida* (Muzac-Tucker et al., 1993). Root crops are not easily digested in their

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Table 1. Proximate composition of raw and boiled *D. alata*.

Sample	Ash (%)	Lipids (%)	Moisture (%)	Fibre (%)	Protein (%)	CHO (%)	Energy (kcal/100 g)
RWY	2.93[a]	1.15[a]	6.79[a]	2.31[a]	10.27[a]	76.57[d]	357.65[c]
WYB30	2.70[b]	0.84[b]	4.85[b]	1.69[b]	9.12[b]	80.79[c]	367.36[ab]
WYB60	2.48[c]	0.15[c]	4.74[c]	1.52[c]	8.11[c]	83.02[b]	363.94[b]
WYB90	2.05[d]	0.09[c]	4.11[d]	1.37[d]	7.10[d]	85.20[a]	370.01[a]

Means with different letters on the same column are significantly different (P<0.05). RWY = Raw *D. alata*, WYB30 = *D. alata* boiled for 30 min (at 100°C), WYB60 = *D. alata* boiled for 60 min, WYB90 = *D. alata* boiled for 90 min.

natural state and should be cooked before they are eaten. Cooking improves their digestibility, promotes palatability and improves their keeping quality as well as making the roots safer to eat. However, cooking may affect the nutritional composition and phytoconstituents in food. The objective of this study is to evaluate the nutritional and phytochemical composition of yams and how they are affected by cooking duration.

MATERIALS AND METHODS

Water yam (*D. alata*) was obtained from the yam program of National Root Crop Research Institute, Umudike. The tubers were washed and divided into 2 portions of 1 kg each. One portion was peeled, washed and chipped with a chipping machine (locally fabricated). The second portion was washed, peeled and cooked by boiling in distilled water at 100°C for 30, 60 and 90 min; and then chipped with a chipping machine (locally fabricated). The raw and boiled chips were spread thinly on a dark nylon and sun dried (at 40°C for 48 h). The dried yam chips were then milled into powder using a Thomas Wiley mill (model ED-5) and stored in air tight containers before analysis. The AOAC (1990) method was used to determine the proximate composition of the yam flour. The method of Obadoni and Ochuko (2001) was adopted for the determination of the alkaloid, saponin, phenol and tannin composition while the method of Boham and Kocipai (1994) was used in the flavonoid content determination of the yam flour. The analysis was done in triplicates and data collected were analysed by analysis of variance (ANOVA) to indicate the significant differences between mean values of the different results using a SAS system 2008 version. Significant level was established at $P < 0.05$.

RESULTS

The proximate composition of raw and boiled water yams are shown in Table 1. Protein content of the raw tuber was 10.27%, significant differences (P<0.05) were observed between the crude protein content of the raw and boiled tubers. The crude protein contents reduced significantly (p<0.05) with increase in the boiling time. Boiling effected a 30.83% reduction in the crude protein of *D. alata* after boiling for 90 min. Boiling *D. alata* for 90 min significantly reduced the ash content from 2.93% to 2.05% resulting in 29.91% loss in the ash content. Boiling for 30 and 60 min reduced the lipid significantly (P<0.05) from 1.15 to 0.15% but further boiling for 90 min did not affect the lipid significantly. The crude fibre content reduced significantly with boiling from 2.31 to 1.37%. On the other hand the carbohydrate composition of *D. alata* increased significantly (p<0.05) with boiling time from 76.57 to 85.20%.

The level of phytochemicals in *D. alata* is shown in Table 2. *D. alata* had 2.71% of saponin; the saponin levels in the boiled samples were reduced significantly when compared with the raw sample. The levels of alkaloids in the tubers ranged from 2.765% when raw to 0.60% when boiled for 90 min. The levels were reduced significantly (p < 0.05) by boiling when compared to the raw samples. The concentration of flavonoids in raw *D. alata* was 1.375%, boiling for 30 min significantly reduced it to 0.93%, boiling for 60 min further reduced it significantly to 0.65%, however further boiling for 90 min did not significantly affect the flavonoid content. Raw *D. alata* had phenol concentration of 1.91%; the variation in phenol content cannot be solely attributed to heat application. *D. alata* had 0.21% tannin content, which reduced with boiling. A loss of 14% tannin content was observed in *D. alata*, after boiling for 90 min.

DISCUSSION

Protein content of raw *D. alata* was 10.27%, a similar result was obtained by Lebot *et al*. (2005). The value obtained for the raw *D. alata* were however, comparably higher than reported values of 5.15% for white yam and 3.64% for sweet potato (Alaise and Linden, 1999). Significant differences (P<0.05) were observed between the crude protein content of the raw and boiled tubers. This reduction may be as a result of the loss of free amino acids which took place through leaching. Ash content is a reflection of the mineral status, even though contamination can indicate a high concentration in a sample. Ash content of the raw tubers were 2.93%, a comparable result has been reported for *D. alata* tubers (Lebot *et al*. 2005). The significant (p<0.05) reduction in ash content of the tubers with increased boiling period is in agreement with the results of Onu and Okongwo (2006), who recorded decrease in ash content of pigeon pea seeds from 5.50% (raw seeds) to 4.00% (30 min boiled seeds). These losses could be as a result of leaching of the minerals into the boiling water. The observed decrease in ash content after cooking implies

Table 2. Effect of boiling on the phytochemical composition of *D. alata*.

Sample	Alkaloid (%)	Flavonoid (%)	Saponin (%)	Tannin (%)	Phenol (%)
RWY	2.77[a]	1.38[a]	2.71[a]	0.21[a]	1.91[a]
WYB30	1.91[b]	0.93[b]	1.37[b]	0.16[b]	1.24[c]
WYB60	0.61[c]	0.65[c]	1.23[c]	0.14[c]	1.66[b]
WYB90	0.60[d]	0.61[c]	1.03[d]	0.18[b]	1.21[d]

Means with different letters on the same column are significantly different (P<0.05); RWY = Raw *D. alata*, WYB30 = *D. alata* boiled for 30 min (at 100°C), WYB60 = *D. alata* boiled for 60 min, WYB90 = *D. alata* boiled for 90 min.

that the potential ability of these tubers to supply essential minerals has been reduced. This is in accordance with the observation of Onyeike and Oguike (2008) on boiled groundnut (*Arachis hypogaea*) seeds. According to the authors, this may be due to water absorption during boiling leading to dilution and hence, low amount of ash.

Lipids are a distinct and diverse set of small molecules consisting of eight general compound classes including: Fatty acyls, glycerolipids, glycerophospholipids, sphingophospholipids, sterol lipids, prenol lipids, saccharolipids and polyketides. The lipid content (1.15%) was quite reasonable as all root crops contain very low lipid content (Ekpeyong, 1984). The lipid content of the raw sample was comparably higher than that of white yam, 0.56% but lower than that of sweet potato, 0.95% (Alaise and Linden, 1999). Boiling reduced the lipid content of the *D. alata*. However the percentage level of reduction is dependent on the duration of boiling as observed in Table 1. The fibre content of raw water yam (2.305%) is comparably higher than that of polished rice, 0.2% and sweet potato, 0.17% (Alaise and Linden, 1999). Decrease in Crude fibre with increase in duration of cooking agrees with the report of Akinmutimi (2007), who worked on mucuna species. The carbohydrate contents of raw water yam (76.570%) agrees with the work of Onyenuga (1968), which reported that the dry matter of most root and tuber crops is made up of about 60 to 90% carbohydrate. The carbohydrate values are comparable to that obtained by Longe (1986) for white yam (78%), water yam (75.65%) but lower than the carbohydrate value for sweet potato (82.55%). The increase in carbohydrate content with boiling observed in this work may have been due to the fact that carbohydrates may have absorb water to bulk up via cross-linking reaction probably induced by heat generated by boiling. This may increase the stability of the carbohydrates thereby enhancing resistance to further heat (Nzewi and Egbuonu, 2011).

Boiling resulted in reduction of all the phytochemicals analysed in this study, which is in agreement with Farris and Singhu (1990) and Balogun *et al*. (2001) reports, which state that most anti-nutritional factors in food can be reduced by proper application of heat. The reduction increased as boiling period increased. This trend may be due to higher ability of hydrolyzing the anti-nutritional factors as boiling period increased. The determination of the anti-nutritional substances was of interest because of their toxicity in yams, negative effects on mineral bioavailability and their pharmacological effect. These metabolites occur in varying concentrations in yam tubers.

Saponin is an antinutritional factor whose toxicological effects should be balanced with its benefits. Some of the general properties of saponins include formation of foams in aqueous solution, hemolytic activity and cholesterol binding properties and bitterness (Sopido *et al*., 2000). Saponins natural tendency to ward off microbes makes them good candidates for treating fungal and yeast infections. These compounds serve as natural antibiotics, which help the body to fight infections and microbial invasion (Sopido et al., 2000). The availability of alkaloids in the tubers of *D. alata* indicates that yam tubers cannot be eaten raw. 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 (Okaka et al., 1992).

Flavonoid concentrations were significantly (p<0.05) affected by boiling, this confirms the work of Mc Williams (1979) which reported that flavonoids are destroyed by heat processing methods like drying, roasting and boiling. Flavonoids are widely distributed group of polyphenolic compounds, characterized by a common benzopyrone ring structure that has been reported to act as antioxidants in various biological systems. The biological functions of flavonoids apart from its antioxidant properties include protection against allergies, inflamemation, free radicals, platelet aggregation, microbes, ulcers, viruses and tumors (Okwu, 2004; Okwu and Omodamiro, 2005). Flavonoids reduce cancer by interfering with estrogen synthetase, an enzyme that binds estrogen to receptors in several organs (Farquer, 1996; Okwu and Omodamiro, 2005).

In some species of yam tubers, browning reactions occur when the tissues are injured and exposed to air. This type of browning is due to the oxidation of phenolic constituents, especially o-hydroxy or trihydroxy phenolics, by a phenol oxidase present in the tissue (Martin and Rubeste, 1976). Phenol content of 1.91% was identified in *D. alata*; the presence of phenols indicates that Dioscorea species could act as anti-inflammatory, anticlotting, antioxidant, immune enhancers and hormone modulators (Okwu and Omodamiro, 2005). There was no regular pattern on how cooking affected the phenol content of *D. alata*.

Tannin affects the nutritive value of food products by forming complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption (Osuntogun et al., 1989). They also bind iron, making it unavailable (Aletor and Adeogun, 1995) and other evidence suggests that condensed tannins may cleave DNA in the presence of copper ions (Shirahata *et al*., 1998). Tannin content of 0.21% was identified in *D. alata*, a similar report was given by Akin-Idowu *et al*. (2009). The reduction of tannin concentration of boiled Dioscorea varieties is expected, since earlier report indicated that processing methods such as soaking, boiling and fermentation lowered the tannin contents of the foods (Jude *et al*., 2009). The decrease in the levels of tannin during cooking may be due to the thermal degradation and denaturation of the tannin as well as the formation of insoluble complexes (Kataria et al., 1989). The bitter principle of the wild *D. dumetorum* may be due to the presence of tannins in them. The trace quantities of tannin available in yam tubers act as a repellant against rots in yams.

Conclusion

From the results obtained in this study, it can be concluded that boiling has both positive and negative effect on water yam (*D. alata*). The positive effect will be derived from the reduction of the anti-nutritional factors while the negative effect is as a result of the reduction of nutritional factors. It is important to avoid overcooking since from the data obtained, it has been shown that the longer the cooking, the higher the loss in nutrients. A cooking time of between 30 and 60 min is recommended for *D. alata*.

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