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Nutritional and Antinutritional Characterization of Two Wild Yam Species from Abakaliki, Southeast Nigeria

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ABSTRACT

The nutritional and antinutritional characterization of the two wild yam varieties, known as *okpura* and *ighobe* in the local language of Ikwo people in Abakaliki, Nigeria, were analysed. Protein was higher in *Ighobe* (3.37%) than *okpura* (2.21%). Carbohydrate was also higher in *okpura* (85.16%) than *ighobe* (78.71%). The crude fibre contents of *okpura* and *Ighobe* were 3.56% and 1.52% respectively. The fat contents of the two wild yam species were found to be 6.01% (*okpura*) and 13.03% (*ighobe*). *Okpura* was higher in K (145.33), Na (5.40), Mg (9.47) and Mn (0.032) while *ighobe* was higher in Ca (56.11) all in mg/100g. The concentrations of three anti-oxidant vitamins (A, C and E) and two B vitamins (Thiamine and Niacin) in the wild yam species were also determined. The obtained concentrations of the anti-oxidant vitamins were respectively 1.75 mg/100g in *okpura* and 1.54 mg/100g in *ighobe*, 0.99 mg/100g in *okpura* and 0.98 mg/100g in *ighobe*, and 3.93 IU/100g (2.632 mg/100g) in *okpura* and 2.50 IU/100g (1.674 mg/100g) in *ighobe*, while thiamine and niacin were respectively 0.11 mg/100g in *okpura* and 0.15 mg/100g in *ighobe* and 0.82 mg/100g in *okpura* and 0.98 mg/100g in *ighobe*. The concentrations of alkaloids, saponins, tannin, HCN and oxalate differed significantly between the yam species ($P<0.05$), while flavonoids, phenols and phytate did not show significant variations. The results of this study revealed that the wild yam species are good nutritionally, containing proximate components, minerals and vitamins in amounts comparable to cultivated species in Nigeria. However, they have high contents of phytochemicals most of which are anti-nutritional substances, but these are significantly reduced during cooking and cannot prevent their full utilization as food sources. Thus, the rural poor in Abakaliki area of Nigeria who use these wild yam species as alternative food sources are not at any special health risk.

Keywords: Wild yams, okpura, ighobe, nutrients, antinutrients, Abakaliki and rural poor.

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INTRODUCTION

Yams belong to the genus *Dioscorea* and family *Dioscoreceae* [6]. Yams are root and tuber crops cultivated for the consumption of their starchy tubers as a valuable source of carbohydrate in Africa, Asia, Latin America and Oceania [2, 23]. FAO [11] noted that West Africa alone produces over 90% of the world's yam production with Nigeria being the largest producer producing above 50% of total world production [24]. Mro and Mtotmwem (1987), reported that there are about 50 – 60 species of yam in Nigeria, but majority of these important food crops have not been exploited for food use as only about five or six species are utilized as food. Amusa *et al* [3] listed the most cultivated species in Nigeria as *D. rotundata* (white yam), *D. cayenesis*, (yellow or guinea yam) and *D. alata* (water yam) and there are many cultivars of these species. Some of the unexploited species grow in the forests as wild yams. Shortage of foods has forced rural dwellers in some parts of Nigeria to source some of the wild yam species from the forest for food. In the rural areas of Abakaliki, Southeast Nigeria, two wild grown yam cultivars known in the people's local language as *okpura* and *ighobe* are commonly harvested from forests by the rural poor and eaten in porridge form. There is need to investigate the nutritional and anti-nutritional qualities of these rare food resources. Hence the study determined the proximate compositions and levels of some mineral elements, vitamins and phytochemicals in the wild yam cultivars.

MATERIALS AND METHODS

Sample Collection

The two wild yam species used in this study were sourced from Ikwo Local Government Area of Ebonyi State Nigeria where they are most commonly used as food sources by the rural women. One of the yams was identified as a cultivar of the *Dioscorea villosa spp* and called *okpura* in the people's dialect while the other called *ighobe* was yet to be identified at the time of this research report.

Proximate Analysis

All the analyses were conducted in the Central Laboratory of the National Root Crops Research Institute, Umudike, Abia State, Nigeria. Prior to the analysis, the yam tubers were peeled, washed clean in tap water and cut into thin slices with a kitchen knife. A portion of these fresh slices was used to determine moisture content by a method described by Onwuka (2005). The remaining portion was dried in hot air oven at a temperature of 55^{o}C for 24hr [17]. Thereafter, the dried chips were ground into fine powder using laboratory mortar and pestle. The flour was used for determination of other proximate components. Crude protein content was determined by semi-micro kjeldahl method [4]. Fat content was determined by continuous solvent extraction method [27]. Crude fibre was estimated using the Wende method (James, 1995), total ash content was determined by methods of Onwuka (2005), while carbohydrate content was estimated by arithmetic difference method [16].

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Mineral Element Analysis

Ashing and digestion of the yam flour samples were done according to methods described by Onwuka (2005) and the digestates were used for mineral element determinations. Phosphorus concentration was determined by the vonadomolybdate spectrophotometric method described by James [16]; calcium and magnesium were determined by EDTA complexiometric titration method of Udoh [30]; sodium and potassium by flame photometric method described in AOAC [4], whereas manganese, zinc, lead and cadmium levels were determined by AAS method [16].

Vitamin Analysis

Vitamin C was estimated by titration while vitamins A, E, B1 and B3 were measured spectrophotometrically using methods described by Onwuka (2005).

Phytochemical Analysis

Tannin was estimated using the Folin Dennis colorimetric method (Kirk and Sawyer, 1998); saponin, alkaloid and flavonoid by methods described by Harborne [15]; phenol by spectrophotometric method of AOAC [4], whereas hydrogen cyanide content was measured by the alkaline picrate colorimetric method described by Balogopalin *et al.,* (1988).

Table 1: Proximate Compositions (%) of two edible wild yam varieties from Abakaliki, Nigeria

Sample	Protein	Crude Fibre	Moisture Content	Ash Content	Fat	Carbohydrate
Okpura	2.21±0.07[b]	3.50±0.06[a]	76.37±0.14[b]	3.13±0.04[b]	6.01±0.04[b]	85.16±0.09[a]
Ighobe	3.37±0.11[a]	1.54±0.02[b]	80.15±0.27[a]	3.35±0.09[a]	13.03±0.08[a]	78.71±0.05[b]

*Means with the same letter on the same column are not significantly different at 0.05 probability level. Values are means ± standard deviation of triplicate determinations.

Table 2: Contents of some mineral elements (mg/100g) in two edible wild yam varieties from Abakaliki, Nigeria

Mineral	*Okpura*	*Ighobe*
Potassium	145.33 ± 1.15[a]	104.00 ± 2.00[b]
Calcium	28.06 ± 4.01[b]	56.11 ± 0.006[a]
Sodium	5.40 ± 0.10[a]	3.30 ± 0.10[b]
Phosphorus	43.82 ± 0.49[a]	45.00 ± 0.64[a]
Magnesium	9.47 ± 0.23[a]	7.33 ± 0.23[b]
Manganese	0.032 ± 0.00[a]	0.024 ± 0.00[b]
Zinc	0.26 ± 0.00[a]	0.25 ± 0.00[a]
Cadmium	0.02 ± 0.00[a]	0.028 ± 0.00[a]
Lead	0.008 ± 0.00[a]	0.008 ± 0.00[a]

*Means with the same letter on the same row are not significantly different at 0.05 probability level. Values are means ± standard deviation of triplicate determinations.

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Table 3: Contents of some vitamins in two edible wild yam varieties from Abakaliki, Nigeria

Sample	Vit. A (mg/100g)	Thiamine (mg/100g)	Vit. C (mg/100g)	Vit. E (IU/100g)	Niacin (mg/100g)
Okpura	1.75±0.179[a]	0.11±0.029[a]	0.99±0.017[a]	3.93±0.635[a]	0.82±0.014[b]
Ighobe	1.54±0.310[a]	0.15±0.019[a]	0.98±0.020[a]	2.50±0.606[b]	0.98±0.014[a]

*Means with the same letter on the same column are not significantly different at 0.05 probability level. Values are means ± standard deviation of triplicate determinations.

Table 4: Contents of some phytochemicals in two edible wild yam varieties from Abakaliki, Nigeria

Mineral	*Okpura*	*Ighobe*
Alkaloid (%)	0.373±0.012[a]	0.2867±0.012[b]
Saponin (%)	0.513±0.031[a]	0.3667±0.0121[b]
Flavonoid (%)	1.233±0.012[a]	1.1667±0.012[a]
Tannin (%)	0.463±0.012[b]	0.603±0.006[a]
HCN (mg/100g)	26.687±0.081[a]	21.827±0.058[b]
Phenol (%)	0.387±0.003[a]	0.364±0.002[a]
Oxalate (%)	0.660±0.007[a]	0.465±0.006[b]
Phytate (%)	0.460±0.012[a]	0.483±0.001[a]

*Means with the same letter on the same row are not significantly different at 0.05 probability level. Values are means ± standard deviation of 3 determinations.

RESULTS AND DISCUSSION

Proximate Composition

Yam tuber is essentially a starchy food with its principal nutritional function being the supply of calories to the body (Onwueme, 1978). Two wild yam varieties, known as *okpura* and *ighobe* in the local language of Ikwo people in Abakaliki, Nigeria, where the samples were sourced, were analysed in this study for their proximate principles. The wild yam cultivar *okpura* was identified as *Dioscorea villosa,* while efforts to identify *Ighobe* at the time of this report have not been successful. The proximate compositions of the wild yams are shown in Table 1. Statistical analysis showed significant differences in the means of all the proximate components between the two wild yam varieties ($P < 0.05$).

Protein content was higher in *Ighobe* (3.37%) than *okpura* (2.21%). These values are both significantly higher than 1.53% (1.53g/100g) given as the average protein content of *Dioscorea spp* in the United States Department of Agriculture (USDA) National Nutrient Database available online at www.nutrition-and-you.com and compare well with 1-3% and 1.4-3.5% reported for cultivated yam species by Coursey [7] and Osagie [20] respectively. Thus, these wild yams are good and even better than some cultivated species in terms of protein content. However, the values are more than two times lower than 7.82% reported for white Guinea yam (*Dioscorea rotundata*) by Lawal *et al* [17].

Carbohydrate was higher in *okpura* (85.16%) than *ighobe* (78.71%). These carbohydrate values are very similar to those of *Dioscorea alata* (83.33%) and *Dioscorea esculenta* (83.08%)

(FAO, 2001) and are both significantly higher than 69.50% reported for cultivated species by Lawal *et al* [17] and much higher than 16.4 – 31.8% by Osagie [20] for cultivated species. Therefore, these species are excellent sources of carbohydrate.

The crude fibre contents of *okpura* and *Ighobe* were 3.56% and 1.52% respectively. According to the result, *okpura* is about 2.3 times higher than *ighobe* in fibre content. The obtained fibre content of *okpura* is not very different from 4.1% for yams (USDA National Nutrient Database) but that of *ighobe* is significantly lower. However, both species contain amounts of fibre within the range widely reported for yams [20, 1] suggesting that these wild yam species qualify as edible yams in terms of fibre content.

The result showed the ash contents of the two wild yam species to be about the same, 3.35% (*okpura*) and 3.15% (*ighobe*). These values are high when compared to 0.6-1.7% reported for cultivated yam species in Nigeria by Osagie [20]. They are also higher than 1.84% reported for *Dioscorea rotundata* by Lawal *et al* [17]. Although the values are lower than those for *Dioscorea alata, Dioscorea esculenta* and *rotundanta* as reported by FAO [11], the result indicates that the samples could be good sources of nutritionally essential minerals and trace elements [20].

According to the result, the two yam samples are high in moisture content, 76.37% (*okpura*) and 80.15% (*ighobe*). However, the moisture contents of these yams species are consistent with the values variously reported in literature for common cultivated species in Nigeria such as *Dioscorea bulbifera* (61.93%) [1], *Dioscorea alata* (73.83%) [11] and 65-81% for all cultivated species [20]. Moisture content is an index of perishability and storability of food materials, so the amounts of moisture detected in these yam species indicate that high perishability may not be a reason why these species have not been considered for domestication.

The fat contents of the two wild yam species were found to be 6.01% (*okpura*) and 13.03% (*ighobe*). The fat value detected in *ighobe* is about 2.2 times higher than that of *okpura*. Both values are much higher than 0.17% for yams generally (USDA National Nutrient Database) and many times higher than 0.2-0.4% for common cultivated yams in Nigeria [20] and 0.84% for *Dioscorea rotundata* [17]. Because of the very high fat contents of these yam species, there is need to investigate the quality of the fat as part of the safety assessment of the yams.

Mineral Element Composition

Table 2 shows the concentrations of nine mineral elements, including five major elements (K, Ca, Na, P and Mg) and four trace elements (Mn, Zn, Cd and Pb) in the two wild yam species. The result shows that the yam species contain appreciable amounts of the major elements while the trace elements are present in trace amounts. K, Ca, Na and Mg varied significantly between the two yam species, while no significant variation was detect for P, Mn, Zn, Cd and Pb. Of the nine mineral elements, the dominant ones in a descending order are K (104.00 - 145.33), P (43.82 - 45.00) and Ca (28.06 - 56.11) all in mg/100g.

Okpura is higher in K (145.33), Na (5.40), Mg (9.47) and Mn (0.032) while *ighobe* is higher in Ca (56.11) all in mg/100g. The rest of the elements were present in about the same amounts in both yam species. Although the study generally detected lower amounts of the major mineral elements compared to values reported for cultivated species by Osagie (1992) and USDA National Nutrient Database especially for K, Na and Mg, we consider these wild yam species good sources of these nutritionally important mineral elements. The differences observed might be due to different growth conditions, genetic factors, geographical variations in soil loads of the minerals, efficiency of mineral uptake, and the analytical procedure employed [20, 21].

Concentrations of the trace elements in the yam species [Mn(0.024-0.032), Zn(0.25-0.26), Cd(0.02-0.028) and Pb(0.008) all in mg/100g] are all within permissible limits (FAO/WHO 1984). The permissible limit set by FAO/WHO (1984) for Cd in edible plants is 0.21 ppm, Pb is 0.43 ppm and that of Zn is 27.4 ppm. The low concentrations of the trace elements in these wild yam species indicate their food safety. The ratio of Na/K in any food is an important factor in prevention of hypertension and arteriosclerosis, with K depressing and Na enhancing blood pressure [25]. The ratios of Na/K detected in this study 1:26.9 (*opkura*) and 1:31.5 (*ighobe*) are significantly higher than the critical values (1:10) suggesting that the yam species would be good in preventing these diseases. Consumption of these wild yams may have contributed to the near complete absence of cases of high blood pressure among the rural poor in the study area in the past unlike the present time when such food resources are completely neglected in preference to modern foods.

Vitamin Contents

The concentrations of three anti-oxidant vitamins (A, C and E) and two B vitamins (Thiamine and Niacin) in the wild yam species were also determined (Table 3). The obtained concentrations of the anti-oxidant vitamins were respectively 1.75 mg/100g in *okpura* and 1.54 mg/100g in *ighobe*, 0.99 mg/100g in *okpura* and 0.98 mg/100g in *ighobe*, and 3.93 IU/100g (2.632 mg/100g) in *okpura* and 2.50 IU/100g (1.674 mg/100g) in *ighobe*, while thiamine and niacin were respectively 0.11 mg/100g in *okpura* and 0.15 mg/100g in *ighobe* and 0.82 mg/100g in *okpura* and 0.98 mg/100g in *ighobe*. When compared to standard concentrations in cultivated yams, vitamins A and C contents of the wild yam species are low while their contents of Vitamin E and niacin are high. Thiamine contents of the two species are at par with the standards. The standards are 138 IU/100g (92.41 mg/100g) for vitamin A, 17.1 mg/100g for Vitamin C, 0.35 mg/100g for Vitamin E, 0.112 mg/100g for thiamine and 0.552 mg/100g for niacin (USDA National Nutrient Database). Compared to the levels of the vitamins in cultivated Nigerian yams, thiamine and niacin contents are slightly high while vitamin C is very low in the wild yam species. The mean ranges of vitamins thiamine, niacin and vitamin C in cultivated Nigerian yams according to a comprehensive report by Osagie (1992) are 0.01-0.11, 0.30-0.80 and 4.00-18.0 all in mg/100g. The author did not give the values of vitamins A and E.

Phytochemical/anti-nutrient Composition

Determination of the phytochemical/anti-nutritional substances in the wild yam species was necessary because of their toxicity, negative effects on mineral bioavailability and their pharmacological effects. The levels of alkaloids, saponins, flavonoids, tannins, cyanides, phenols, phytates and oxalates in the yam varieties are given in Table 4. The concentrations of alkaloids, saponins, tannin, HCN and oxalate differed significantly between the yam species ($P<0.05$), while flavonoids, phenols and phytate did not show significant variations. The concentrations of flavonoids and tannins detected in these wild yams species are generally higher while alkaloids, saponins, and phenols and lower than reported for raw water yam (*D. alata*), a popular edible yam, by Ezeocha and Ojimelukwe [9]. Phytate and oxalate concentrations are much higher than 238.26mg/100g and 209 mg/100g reported for afang (*Gnetumafricanum*) seeds by Ekpo [8], which the author noted are higher than tolerable limits permissible for children. The levels of the anti-nutrients in the raw yam samples are generally higher than permissible limits which is also true of cultivated edible yams [9], but the good thing is that heat and most processing applications significantly reduce or totally eliminate most of the anti-nutrients [5, 12, 22, 30]. The implication is that yams including these wild species should not be eaten without proper processing. So, high levels of anti-nutrients may not be a major reason these yam species were not selected for cultivation in the region.

The high content of these phytochemicals may be of immense pharmacological benefits. For instance, phytate, lectins, phenolic compounds, amylase inhibitors and saponins have been shown to reduce blood glucose, plasma cholesterol, triglycerides levels and cancer risks [13, 26, 28, 33]. Sopido *et al* [26] described saponins as natural antibiotics, which help the body to fight infections and microbial invasion. Okaka *et al* [18] added that alkaloids are known for their pharmacological effects rather than their toxicity but when alkaloids occur in high levels in foods, they cause gastro-intestinal upset and neurological disorders. Because of the important health benefits of some anti-nutrients, Thompson (1993) suggested a change in their name.

CONCLUSION

The results of this study show that these wild yam species are good nutritionally, containing proximate components, minerals and vitamins in amounts comparable to cultivated species in Nigeria. They actually have high contents of phytochemicals most of which are anti-nutritional substances, but these are significantly reduced during cooking and cannot prevent their full utilization as food sources. These however could enhance their medicinal values. So, the rural poor in Abakaliki area of Nigeria who use these wild yam species as alternative food sources are not at any special risk. The fact that the yams are not cultivated in the area may be attributed to their small tuber size (low yield) rather than their nutritional values.

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