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Nutritional evaluation of wild yam (*Dioscorea* spp.) tubers of Nepal

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Abstract

Wild yams make a significant contribution to diets of tribal people in Nepal. However, there is insufficient study of their nutritional value. In this paper, four wild yam species: *Dioscorea bulbifera, D. versicolor*, *D. deltoidea* and *D. triphylla*, were studied. The dry matter ranged from 19.8 to 30.5% on a fresh weight basis. The ranges of crude protein, ash, crude fat and crude fibre contents were 1.6–3.1, 0.5–1.2, 0.2–0.3 and 0.6–1.5% of fresh weight, respectively. The ranges of minerals in mg per 100 g fresh weight were K (250–560), Na (4.15–17.8), P (33.1–61.6), Ca (14.3–46.9), Mg (18.3–27.3), Cu (0.10–0.21), Fe (0.39–2.92), Mn (0.14–0.35) and Zn (0.22–0.53). Sulfur-containing amino acids and lysine were the most limiting in all species studied. Nutritional compositions of wild yams were similar to those reported for most cultivated yams in several parts of the world except for the higher value of crude fibre found in our samples.

Keywords: Wild yam; *Dioscorea*; Proximate composition: Amino acid; Essential amino acid; Mineral; EAA score

1. Introduction

Wild yams make a significant contribution both as root crops and vegetables to the diets of tribal people (Chepang, Tharu, Manjhi, Bantar, Danuwar, Tamang) of Nepal, particularly in rural areas where they are freely available. Humans have long been using these wild plants for food (Joshi & Basnet, 1999). Generally, yams are consumed, either boiled, steamed, baked or fried (Gurung, 1995). Many different forms and cultivars of the wild edible yam species are available in different areas and it is likely that these differ in composition and nutritional values. In contrast to cultivated tubers, little is known about the composition of wild tubers and there are reasons to expect that some wild species differ in composition from common agricultural varieties (Schoeninger, Bunti, Murray, & Marlett, 2000). In spite of their importance as a food source, to the best of our knowledge, there are no published studies on the nutritional composition of Nepalese wild yam tubers and information on the nutritional composition of these varieties is scarce. The present study was therefore initiated to evaluate the nutritive values of four species (*Dioscorea bulbifera*, *D. versicolor*, *D. deltoidea* and *D. triphylla*) of wild yam prevalently consumed by the local tribal people in mid-hill and Terai regions of Nepal.

The present paper reports the proximate chemical, mineral and amino acid compositions of wild edible yam tubers of Nepal. The protein nutritional quality of yam was also estimated, from its amino acid composition, by determination of essential amino acid scores.

2. Materials and methods

2.1. Collection and preparation of samples

Wild yam species were collected from the central region (Narayani Zone) of Nepal. The local names, botanical names and local consumption practice of the studied yam tubers are presented in Table 1. Specimens were identified at the National Herbarium Center, Godawari, Kathmandu, Nepal. The samples were

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Table 1
Description of the wild yam tubers used in this study

Local names	Botanical names	Local preparation and consumption practice
Githa	*Dioscorea bulbifera*	Baked in fire coal or steamed and used as staple
Ban Tarul	*Dioscorea versicolor*	Cooked as vegetable or boiled and used as staple
Vyakur	*Dioscorea deltoidea*	Steamed or boiled and used as staple
Varlang	*Dioscorea triphylla*	Steamed or boiled and used as staple

brought to Japan and were stored at 15 °C until processed. Yam tubers were weighed, peeled, cut into small pieces and dried at 40 °C until constant weight was obtained. The dried samples were ground to a fine powder by using an electric grinder (Holloway, Argall, Jealous, Lee, & Bradbury, 1989), and all the analyses were carried out with the flours. The samples were packed into airtight sample bottles and stored in the refrigerator until used.

2.2. Proximate analysis

The moisture content, ash, crude fat, crude protein and crude fibre were determined in accordance with the standard methods of the AOAC (1980). Crude fat was determined by exhaustively extracting samples in a Soxhlet apparatus using anhydrous diethyl ether as the solvent. Crude protein determination involved the use of routine Kjeldhal nitrogen assay (N×6.25). Crude fibre estimates were obtained from the loss in weight on ignition of dried residue following the digestion of fat free samples with 1.25% each of sulfuric acid and sodium hydroxide solutions under specified conditions (AOAC, 1980). Carbohydrate content was determined by difference while calorific values were obtained by the summation of multiplied mean values for protein, fat and carbohydrate by their respective Atwater factors, 4, 9 and 4 (Udosen, 1995). All results for proximate composition are recorded on the basis of edible portion fresh weight of the uncooked sample as g/100 g fresh weight.

2.3. Mineral analysis

The minerals, such as calcium, copper, iron, magnesium, manganese, sodium, potassium and zinc were analyzed after first wet-ashing according to the method prescribed by Onwuliri and Anekwe (1992) with an atomic absorption spectrophotometer (Model No. AA-6400 F, Shimadzu Corporation, Japan). Phosphorus was estimated colorimetrically (UV-visible spectrophotometer, Model No: UV-1600, Shimadzu Corporation, Japan), using potassium dihydrogen phosphate (Wako pure chemicals industries Ltd., Japan) as the standard (AOAC, 1980). All results for mineral composition are recorded on the basis of edible portion fresh weight of uncooked sample as mg/100 g fresh weight.

2.4. Amino acid analysis

The amino acids were estimated following the methods of Spackman, Stein, and Moore (1958). The contents of different amino acids were presented as g/100 g protein. The amino acid contents of reference protein were taken from FAO/WHO (1985). The essential amino acid (EAA) score was calculated according to Siddhuraju, Becker, and Makkar (2000) as follows:

$$\text{EAA score} = \frac{\text{g of EAA in 16 g N of test sample}}{\text{g of EAA in 16 g N of FAO/WHO ref. pattern}} \times 100$$

2.5. Statistical procedure

All determinations were carried out in triplicate for each nutrient analysis. For all analyses, the mean and standard deviation for each of the nutrients analyzed were calculated and reported.

3. Results and discussion

3.1. Proximate composition

The nutritional compositions of wild yam (*Dioscorea*) tubers available in Nepal are presented in Table 2. The moisture and ash contents of yam ranged from 69.5 to 80.2% and 0.5 to 1.2% of fresh weight, respectively. The moisture and ash contents obtained for wild yam species were similar to reported values for tropical yam species from the south pacific region (Bradbury, 1988). The range of crude fibre content of wild yam was 0.6 to 1.5% of fresh weight. The crude fibre contents in the studied yam tubers were higher than reported values for other cultivated yam species (Egbe & Treche, 1984; Lila Babu & Sundaresan, 1990; Ologhobo, 1985; Wanasundera & Ravindran, 1994). Such variation in the crude fibre content might be related to their genetic origin, geographical sources, the level of soil fertility, where they are grown and the harvesting periods.

The crude protein content of wild yam tubers ranged from 1.6 to 3.1% of fresh weight. These values were consistent with the values reported for several cultivated

Table 2
Proximate composition of wild yam tubers (g/100 g fresh weight)[a]

Parameters	*Dioscorea bulbifera*	*Dioscorea deltoidea*	*Dioscorea versicolor*	*Dioscorea triphylla*
Moisture	69.5±0.3	80.2±0.8	80.1±0.1	76.9±0.1
Dry matter	30.5±0.3	19.8±0.8	19.9±0.1	23.1±0.1
Crude protein (N×6.25)	3.1±0.03	1.6±0.06	1.7±0.02	2.3±0.05
Ash	1.2±0.06	0.6±0.02	0.5±0.06	0.6±0.02
Crude fat	0.3±0.03	0.2±0.0	0.2±0.02	0.2±0.02
Crude fibre	1.1±0.1	1.5±0.04	1.1±0.02	0.6±0.02
Total carbohydrate[b]	25.9±0.1	17.4±0.08	17.5±0.1	20.0±0.1
Energy (kcal/100 g fresh weight)[c]	119	78	79	91

[a] Values are means of three determinations±S.D. ($n=3$).
[b] Calculated by difference.
[c] Calculated by using Atwater factors.

tropical yam species from the south pacific region (Bradbury, 1988) and yam species from Sri Lanka (Wanasundera et al., 1994). The higher protein content of *D. bulbifera* indicated its nutritional superiority over the other wild yam species.

The crude fat content ranged from 0.2 to 0.3% of fresh weight. These values are higher than reported values for Cameroonian yam species (Egbe & Treche, 1995) and tropical yam tubers from the south pacific region (Bradbury, 1988). However, these results were consistent with the results of a study by Wanasundera and Ravindran (1994). The carbohydrate content (17.4–25.9% of fresh weight) and energy values (78–119 kcal/100 g fresh weight) recorded in this study are in agreement with those reported for yam (FAO, 1990).

3.2. Mineral composition

The results of the mineral estimation of the wild yam tubers are presented in Table 3. The results show that potassium was the most abundant mineral, ranging from 250 to 560 mg per 100 g fresh weight. These levels are similar to reported values for yam species by others (Bradbury, 1988; Egbe & Treche, 1995; Wanasundera & Ravindran, 1994).

The contents of sodium, phosphorus and magnesium were higher than those reported for Cameroonian yam species (Egbe & Treche, 1995), but are consistent with the values reported for tropical yam species from the south pacific region (Bradbury, 1988) and yam species from Sri Lanka (Wanasundera & Ravindran, 1994). The calcium contents were higher than reported values for several cultivated yam species (Bradbury, 1988; Wanasundera & Ravindran, 1994), but except for *D. deltoidea* the values compare relatively well with the reported values for Nigerian yam species (Adeyeye, Arogundade, Akintayo, Aisida, & Alao, 2000). The discrepancy possibly could be due to both species and environmental differences. The high content of calcium in *D. deltoidea* and *D. triphylla* is due to the high content of calcium oxalate in these tubers (Bhandari, Kasai, & Kawabata, unpublished work). The contents of other micro-nutrients, such as copper, iron, zinc and manganese in the analyzed wild yam species compare relatively well with those obtained for several yam species (Bradbury, 1988; Egbe & Treche, 1984; Ologhobo, 1985), but these values are lower than the study reported by Wanasundera and Ravindran (1994). This study shows that copper was the least abundant mineral in all the wild yam tubers.

3.3. Amino acid composition

Table 4 shows the amino acid compositions of wild yam tubers. Overall, 17 amino acids were determined in

Table 3
Mineral composition of wild yam tubers (mg/100 g fresh weight)[a]

Minerals	*Dioscorea bulbifera*	*Dioscorea deltoidea*	*Dioscorea versicolor*	*Dioscorea triphylla*
K	560±49	340±51	250±4	317±32
Na	17.8±9.8	9.12±1.6	4.91±2.5	4.15±0.7
P	61.61±0.8	33.1±0.6	40.8±0.2	56.6±0.1
Ca	29.3±4.8	46.9±6.2	14.3±1.8	39.7+8.1
Mg	25.9±9.2	22.8±7.1	18.3±3.8	27.3±5.6
Cu	0.21±0.03	0.10±0.0	0.18±0.02	0.18±0.05
Fe	2.92±0.3	1.85±1.0	0.39±0.1	1.00±0.05
Mn	0.35±0.03	0.31±0.02	0.14+0.0	0.25±0.07
Zn	0.53±0.06	0.22±0.04	0.30±0.06	0.39±0.1

[a] Values are the means of three determinations±S.D. ($n=3$).

Table 4
Amino acid compositions of wild yam tubers (g amino acid/100 g protein)[a]

Amino acids	*Dioscorea bulbifera*	*Dioscorea deltoida*	*Dioscorea versicolor*	*Dioscorea triphylla*
Leucine	8.7	7.5	5.1	6.3
Lysine	3.6	3.4	3.4	4.9
Methionine	1.6	1.5	1.0	1.6
Cystine	0.2	0.4	0.1	0.5
Phenylalanine	5.6	4.0	3.1	3.8
Threonine	4.6	3.9	2.8	3.2
Tyrosine	4.0	2.9	2.0	3.8
Valine	5.7	3.9	3.4	4.7
Isoleucine	4.3	3.7	2.8	3.8
Histidine	1.9	1.6	1.4	2.1
Alanine	5.1	4.3	3.5	4.4
Glysine	5.1	4.1	3.1	3.9
Proline	4.4	1.9	2.5	3.4
Serine	6.1	4.1	3.5	3.6
Aspartic acid	11.7	9.9	6.6	8.7
Glutamic acid	13.5	9.9	8.1	11.7
Arginine	4.9	3.6	4.0	7.4

[a] Values are means of three determinations.

each sample. Considerable diversity existed in amino acid composition among the yam tubers. Most of the varieties contained adequate amounts of essential amino acids, except those containing sulfur. All yam tubers tested contained large amounts of aspartic acid and glutamic acid (Table 4). The amino acid composition of *D. bulbifera* was superior to those of other species analyzed, whereas the amino acid composition of *D. versicolor* was found to be poorer than that of other species. The reports on the amino acid composition of yam tubers are limited. However, the amino acid compositions of Nepalese wild yam tubers studied were similar to reported values of several cultivated yam species (Splittstoesser, Martin, & Rhodes, 1973). The amino acid compositions of wild yam tubers were comparatively better than reported values for sweet potatoes (Meredith & Dull, 1979).

Table 5 shows that, among the yam tubers studied, *D. versicolor* was deficient, to a large extent, in a number of essential amino acids compared to the FAO reference amino acid pattern (FAO/WHO, 1985). The essential amino acid contents of *D. bulbifera, D. deltoidea and D. triphylla* were fairly similar to that of the FAO reference pattern, except for the sulfur-containing amino acids, and lysine.

Table 6
Essential amino acid (EAA) score of wild yam tubers[a]

EAA	*Dioscorea bulbifera*	*Dioscorea deltoida*	*Dioscorea versicolor*	*Dioscorea triphylla*
Leucine	132	114	77	96
Lysine	63	60	60	86
Met + Cys	69	73	42	81
Phe + Tyr	155	111	82	123
Threonine	139	118	85	97
Valine	163	112	97	134
Isoleucine	154	132	100	136
Histidine	100	84	74	111

[a] Calculated values according to Siddhuraju et al. (2000).

Table 6 shows the EAA score of wild yam tubers studied. The results show that, among the yam tubers studied, *D. versicolor* was lowest in EAA score. The sulfur-containing amino acids, (Met + Cys) and lysine, turned out to be the most limiting in all species with EAA score ranging between 42–81 and 60–86, respectively. Sulfur-containing amino acids were the limiting ones in all analyzed wild yam tubers. This result agrees well with the study results reported by Splittstoesser et al. (1973). The lysine was also found to be limiting in all wild yam tubers studied, which is contrary to the reports of Splittstoesser et al. (1973). In general, almost all of the essential amino acids studied in wild yam tubers have a high essential amino acid score, which implies that essential amino acids present in these yam tubers have high biological value.

The nutritional composition of wild yam tubers available in the central region of Nepal is similar to that of reported values for several cultivated yam species in various parts of the world. Wild yam tubers analyzed have contained more crude fibre, crude fat and crude

Table 5
Essential amino acid (EEA) composition of wild yam tubers, compared to the FAO/WHO reference protein (g amino acid per 100 g protein)[a]

EAA	FAO/WHO[b]	*Dioscorea bulbifera*	*Dioscorea deltoidea*	*Dioscorea versicolor*	*Dioscorea triphylla*
Leucine	6.6	8.7	7.5	5.1	6.3
Lysine	5.7	3.6	3.4	3.4	4.9
Met + Cys	2.6	1.8	1.9	1.1	2.1
Phe + Tyr	6.2	9.6	6.9	5.1	7.6
Threonine	3.3	4.6	3.9	2.8	3.2
Valine	3.5	5.7	3.9	3.4	4.7
Isoleucine	2.8	4.3	3.7	2.8	3.8
Histidine	1.9	1.9	1.6	1.4	2.1

[a] Essential amino acids only are given except tryptophan, which was not determined.
[b] WHO technical report series No. 724,1985 (Energy and protein requirements report of a joint FAO/WHO/UNU expert consultation); values are recalculated as g amino acid per 100 g protein.

protein. Yam tubers were also found to be fairly good sources of dietary minerals. This result suggested that these less familiar wild tubers should not be ignored. Rather they can be used as a good alternative source of food to alleviate hunger and malnutrition, which are currently big problems in developing countries such as Nepal. We hope that this study will help propagate knowledge on these lesser-known wild yam tubers and stimulate activity to promote their production and utilization as valuable components of a well balanced diet.

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