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SHORT NOTE [NOTA CORTA]

NUTRITIONAL AND ANTI-NUTRITIONAL ATTRIBUTES OF SOME UNDER–UTILIZED TUBERS

[ATRIBUTOS NUTRICIONALES Y ANTINUTRICIONALES DE ALGUNOS TUBERCULOS SUB-UTILIZADOS]

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SUMMARY

The wild edible tubers of *Asparagus racemosus, Curculigo orchioides, Dioscorea bulbifera* var. *vera, Dioscorea oppositifolia* var. *dukhumensis D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla, D. tomentosa* and *Dolichos trilobus* were analyzed for proximate and mineral composition, starch, vitamins like niacin, ascorbic acids and certain anti-nutritional factors. The tubers of *D. oppositifolia* var. *dukhumensis* contained higher quantity of crude protein. The tubers of *A. racemosus* and *Dolichos trilobus* contained higher amount of crude lipids. All the investigated wild tubers had a higher level of manganese content compared to ESADDI of infants, children and adults (NRC/NAS, 1989). The tubers of *D. oppositifolia* var. *dukhumensis, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla* and *D. tomentosa* were found to contain more starch. The amount of niacin were higher in the tubers of *D. tomentosa, D. oppositifolia* var. *oppositifolia* and *A. racemosus* Anti-nutritional factors such as total free phenols, tannins and hydrogen cyanide were also analyzed. It was concluded that wild tubers analyzed are a viable food source.

Key words: Under-utilized tubers; proximate analysis; anti-nutritional factors.

RESUMEN

Los tubérculos comestibles silvestres *Asparagus racemosus, Curculigo orchioides, Dioscorea bulbifera* var. *vera, Dioscorea oppositifolia* var. *dukhumensis, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla, D. tomentosa* y *Dolichos trilobus* fueron analizados en cuanto a su composición proximal, mineral, almidón, vitaminas y algunos factores antinutricionales. Los tubérculos de *D. oppositifolia* var. *dukhumensis* contienen la mayor cantidad de protein cruda. El mayor contenido de lípidos se encontró en *A.racemosus* and *Dolichos trilobus.* Todos los tubérculos analizados contiene un nivel de manganeso mayor a las recomendaciones para infantes y adultos (ESADDI, NRC/NAS, 1989). Los tubérculos de *D. oppositifolia* var. *dukhumensis, D. oppositifolia* var. *oppositifolia, D.pentaphylla* var. *pentaphylla* y *D. tomentosa* tuvieron los mayores niveles de almidón. El contenido de niacina fuer mayor en *D. tomentosa, D. oppositifolia* var. *oppositifolia* y *A. racemosus.* Se reportan los contenidos de fenoles, taninos y ácido cianihidrico. Se concluye que los tubérculos silvestres analizados son una buena alternativa alimentaria.

Palabras clave: Tubérculos; composición química; factores antinutricionales.

INTRODUCTION

The world food crisis has been and will continue to be a major obstacle to humanity. In the developing world, this crisis can only be overcome by increased food production (Hill, 1984). The food shortage is particularly serious when per capita protein intake is considered (Amubode and Fetuga, 1983). The continuing food scarcity, malnutrition and poverty plus population growth in developing countries are promoting scientists to seek more esoteric plant species. Until recently the emphasis in agricultural development has been on the production of stable and traditional export crops, while many other plant species whose importance and benefits are well unknown locally has been largely ignored (Haq, 1983; Rajyalakshmi and Geervani, 1994). Some of the under utilized wild edible food plants have great potential for adding protein to the diet and they fit well into subsistence agriculture (Nas, 1979; Janardhanan, 1990).

In India the cooked wild tubers are known to be consumed by the *Palliyar* tribals (Arinathan *et al*. 2007) living in Grizzled Giant Squirrel Wildlife Sanctuary, Srivilliputhur, South-Eastern slopes of Western Ghats, Tamil Nadu, India. Information regarding the chemical and nutritional content of wild edible tuber is meager (Gopalan *et al.* 1976; Babu *et al*. 1990; Nair and Nair, 1992; Rajyalakshmi and Geervani, 1994; Balagopalan, 2000; Santhakumari *et al.* 2008; Udensi *et al*. 2008; Alozie *et al*. 2009). Studies of nutritional value of wild plant food are of considerable significance since it may help to identify long forgotten food resources. In this context, an attempt was made to understand the chemical composition and anti-nutritional factors of the under-utilized tubers viz., *Asparagus racemosus* Willd, *Curculigo orchioides* Gaertn, *Dioscorea bulbifera* var. *vera* Prain & Burkill, *D. oppositifolia* L. var. *dukhumensis* Prain & Burkill, *D. oppositifolia* L. var. *oppositifolia, D. pentaphylla* L. var. *pentaphylla, D. tomentosa* Koen.ex Spreng and *Dolichos trilobus* L. to suggest ways and means to remove the anti-nutritional/toxins and make the edible tubers as the safe protein sources for mass consumption.

MATERIAL AND METHODS

The wild edible tubers of *Asparagus racemosus* (Asparagaceae), *Curculigo orchioides* (Hypoxidaceae), *Dioscorea bulbifera* var. *vera, D. oppositifolia* var. *dukhumensis, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla, D. tomentosa* (Dioscoreaceae) and *Dolichos trilobus* (Leguminosae) grown in sandy loam soil consumed by the *Palliyar* tribals were collected using multistage sampling technique in three consecutive rainy seasons during August and January (2007-2008) from the Grizzled Giant Squirrel Wildlife Sanctuary (lies between 77°.3´E and 77°.9´E longitude and 9°.1´N and 9°.8´N latitude), Srivilliputhur, Western Ghats, Tamil Nadu, India. The moisture content was determined by drying transversely cut tubers in an oven at 80^0C for 24 hrs and is expressed in percentage basis. The air dried tubers were powdered separately in a Willey Mill to 60 Mesh size and stored in screw cap bottles at room temperature for further analysis. The crude protein content was calculated by multiplying the per cent Kjeldahl (Humphries,1956) nitrogen with the factor 6.25. The remaining components of proximate composition were estimated by AOAC methods (AOAC 1970). The nitrogen free extractives were calculated by difference (Muller and Tobin, 1980). The energy content of the tuber was determined by multiplying the amount of crude protein, crude fat and nitrogen free extractives with the factors 16.7,37.7,16.7 respectively (Siddhuraju *et al.,* 1996). The starch, vitamins like ascorbic acid, niacin were extracted and estimated from the tuber samples following the method of Sadasivam and Manickam, (1996). All samples were triple acid digested. Copper, Zinc, Manganese, Iron, Calcium, Sodium and Potassium were analyzed using an atomic absorption Spectrophtotmeter (ECIL–Electronic Corporation of India Ltd.) (Issac and Johnson, 1975). Phosphorus was estimated calorimetrically (Dickman and Bray, 1940). Anti-nutritional factors like total free phenols (Sadasivam and Manickam, 1996) tannins (Burns, 1971) and hydrogen cyanide (Jackson, 1967), were quantified. All these constituents were analyzed in triplicate.

RESULTS AND DISCUSSION

The crude protein (Table 1) content of the various species of *Dioscorea* tubers investigated in the present study was found to be in agreement with the earlier investigation in the species of *Dioscorea* tubers (Onyilagha and Lowe, 1985; Rajyalakshmi and Geervani, 1994; Akissoe *et al.*, 2001). Among the two varieties of *D. oppositifolia* tubers the variety *dukhumensis* contained more crude protein than the variety *oppositifolia.* The content of crude lipids in the tubers of *A. racemosus, Dolichos trilobus* exhibited more crude lipid content than the earlier reports in the tubers of *D. oppositifolia, D. bulbifera, D. pentaphylla, D. hispida* (Rajyalakshmi and Geervani, 1994) and *D. rotundata* (Akissoe *et al.,* 2001). The crude fibre content in the presently investigated tubers of *Curculigo orchioides, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla* and *A. racemosus* were found to be more than that in the earlier reports in certain tubers such as *D. bulbifera* (Pramila *et al.* 1991), *D. oppositifolia* and *D. pentaphylla* (Murugesan and Ananthalakshmi, 1991) and *D. alata, D. buibifera, D. tomentosa* and *D. wallichi* (Shanthakumari *et al*. 2008). The nitrogen free extractives (NFE) in the tubers of *D. bulbifera* var. *vera, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla, D. tomentosa* and *Dolilchos trilobus* were higher (above 75%). This value is found to be higher than that of the previous studies in the *Dioscorea* sp. (Rajyalakshmi and Geervani 1994; Akissoe *et al.* 2001 ; Pramila *et al.* 1991).

Robinson (1987) reported that a diet that meets two-thirds of the RDA (Recommended Dietary Allowances) values is considered to be adequate for an individual. The tubers of *D. oppositifolia* var. *oppositifolia D. pentaphylla* var. *pentaphylla* and *Dolichos trilobus* were found to contain higher calcium (Table 2) content than that of RDA's of NRC/NAS, (1980) for infants and children. All the investigated tubers were found to contain higher magnesium content than that of RDA's of NRC/NAS (1980) for infants and children. Similarly all the

investigated tubers appeared to have a higher level of manganese content compared to ESADDI of infants, adults and children of NRC/NAS (1989).

The amount of starch (Table 3) estmated in the tubers of *D. oppositifolia* var. *dukhumensis, D. oppositifolia* var. *oppositifolia, D. pentaphylla* var. *pentaphylla* and *D. tomentosa* were higher than that of the earlier reports in the tubers of *Dioscorea* species (Rajyalakshmi and Geervani, 1994). The niacin contents in the tubers of *Asparagus racemosus, Curculigo orchioides and Dolichos trilobus* were found to be higher than in the tubers of *Dioscorea* species (Rajyalakshmi and Geervani, 1994). Among the investigated tubers, *D. bulbifera* var. *vera* registered the highest ascorbic acid content than the tubers of *D. alata* (Udensi *et al*. 2008) and corms of *Colocasia esculenta, Alocasia macrorrhiza* (Pramila *et al*. 1991).

Table.1. Proximate composition of under-utilized tubers (g 100g $^{-1}$) [a]

Name	Moisture	Crude Protein	Crude Lipid	Crude fibre	Ash	NFE	Calorific Value (KJ 100g^{-1})
Asparagus racemosus	78.39 ± 0.31	6.73 ±0.18	10.32 ±0.18	7.35 ±0.40	4.89 ±0.17	70.71	1682.31
Curculigo orchioides	67.44 ±0.23	9.57 ±0.44	4.44 ±0.27	10.22 ±0.12	3.53 ±0.19	72.27	1533.62
Dioscorea bulbifera var. *vera*	68.70 ±0.25	5.16 ±0.23	9.13 ±0.18	1.23 ±0.06	2.91 ±0.30	81.57	1792.59
Dioscorea oppositifolia var. *dukhumensis*	81.90 ±0.18	13.80 ±0.28	6.33 ±0.34	3.92 ±0.02	1.60 ±0.17	74.35	1710.75
Dioscorea oppositifolia var. *oppositifolia*	69.03 ±0.51	6.31 ±0.35	2.51 ±0.21	8.97 ±0.04	6.39 ±0.26	75.82	1466.20
Dioscorea pentaphylla var. *pentaphylla*	73.46 ±0.27	5.38 ±0.13	6.01 ±0.45	7.04 ±0.07	1.58 ±0.11	79.99	1652.26
Dioscorea tomentosa	71.86 ±0.47	8.51 ±0.27	5.88 ±0.19	2.24 ±0.14	2.54 ±0.39	80.83	1713.71
Dolichos trilobus	72.38 ±0.27	7.08 ±0.36	10.80 ±0.21	3.16 ±0.10	3.02 ±0.28	75.94	1793.60

NFE: Nitrogen Free Extractives

[a] all values are means of three determinations expressed in dry weight basis. ± denotes standard error.

Table 2. Mineral composition of under-utilized tubers (mg 100 g $^{-1}$)[a]

Name	Na	K	Ca	Mg	P	Zn	Mn	Fe	Cu
Asparagus racemosus	25.05 ±0.32	548.00 ±0.14	120.30 ±0.14	280.10 ±0.06	79.42 ±0.09	2.06 ±0.03	13.80 ±0.14	21.20 ±0.03	3.20 ±0.01
Curuligo orchioides	32.54 ±0.08	668.00 ±0.58	440.34 ±0.11	560.30 ±0.11	88.60 ±0.86	2.48 ±0.03	5.24 ±0.01	124.38 ±1.21	2.34 ±0.02
Dioscorea bulbifera var.*vera*	66.78 ±0.44	1600.31 ±1.48	238.15 ±0.09	441.17 ±0.08	134.14 ±0.53	1.30 ±0.01	11.60 ±0.12	4.90 ±0.01	2.74 ±0.01
Disocorea oppositifolia var.*dukhumensis*	123.00 ±0.38	1648.00 ±0.84	230.00 ±0.33	648.33 ±0.16	54.08 ±0.12	1.40 ±0.01	6.80 ±0.22	49.10 ±0.13	11.50 ±0.28
Dioscorea oppositifolia var.*oppositifolia*	110.18 ±0.14	1561.00 ±0.98	880.60 ±0.44	530.48 ±0.12	88.46 ±0.22	5.24 ±0.13	8.44 ±0.04	32.00 ±0.51	2.78 ±0.01
Discorea pentaphylla var. *pentaphylla*	85.24 ±0.11	1341.60 ±1.41	640.10 ±0.54	440.00 ±0.32	126.10 ±1.01	3.22 ±0.11	2.32 ±0.03,	113.48 ±0.12	16.60 ±0.13
Dioscorea tomentosa	35.00 ±0.08	1345.41 ±2.31	240.30 ±0.13	192.00 ±0.04	98.68 ±0.62	6.20 ±0.12	1.10 ±0.01	23.66 ±0.04	1.44 ±0.01
Dolichos trilobus	148.33 ±0.34	775.10 ±1.21	680.00 ±0.78	620.00 ±0.11	115.10 ±0.66	4.44 ±0.03	22.14 ±0.08	16.60 ±0.23	2.70 ±0.06

[a] all values are means of three determinations expressed in dry weight basis.

± denotes standard error.

Table 3. Starch and Vitamins (Niacin and Ascorbic acid) content of under-utilized tubers [a]

Name	Starch g $100g^{-1}$	Niacin mg $100g^{-1}$	Ascorbic acid mg $100g^{-1}$
Asparagus racemosus	25.35 ± 0.18	70.66±0.32	45.79±0.15
Curculigo orchioides	36.47±0.78	23.85±0.10	14.43±0.13
Dioscorea bulbifera var.*vera*	18.10±0.07	23.69±0.35	106.52±0.11
Dioscorea oppositifolia var. *dukhumensis*	48.13±0.03	17.64±0.21	104.79±0.31
Dioscorea oppositifolia var. *oppositifolia*	40.37±0.46	64.65±0.12	80.57±0.12
Dioscorea pentaphylla var. *pentaphylla*	42.58±0.31	53.51±0.27	91.65±0.38
Dioscorea tomentosa	49.86±0.76	88.36±0.12	55.68±0.44
Dolichos trilobus	32.66±0.28	19.99±0.27	57.28±0.56

[a] all values are means of three determinations expressed in dry weight basis.
± denotes standard error.

Among the various species of *Dioscorea*, the tubers of *D. bulbifera* var. *vera* contained more free phenols (Table 4). This value was higher than that of the earlier studies in the tubers of *Ipomoea batatas* (Adelusi and Ogundana, 1987), *D. esculenta*, *D. alata*, *D. rotundata* (Babu *et al.* 1990; Sundaresan *et al.* 1990) and *Manihot esculenta*, *Ipomoea batatas* (Babu *et al.* 1990). The tubers of *D. bulbifera* var. *vera* contained more tannin when compared with other *Dioscorea sp.* (Udoessien and Ifon, 1992). The phenols and tannins are water-soluble compounds (Uzogara *et al.* 1990) and as such can be eliminated by soaking followed by cooking (Singh, 1988; Murugesan and Ananthalakshmi 1991; Kataria *et al.* 1989; Singh and Singh, 1992). Recent researchers report that the phenolic compound is the main human dietary antioxidant and has decreased incidence of chronic diseases. (Padmaja *et al.* 2005).

Hydrogen cyanide is known to cause acute or chronic toxicity. The content of HCN levels in the presently investigated tubers were below the lethal level i.e. 0.36 mg/100g (Oke, 1969) and comparable with those of *Manihot utilisima*, *M. palmate* (Oke, 1975) and *M. esculenta* (Nambisan and Sundaresan, 1990)) and in the *Dioscorea* species (Udoessien and Ifon, 1992).

CONCLUSION

Based on the nutritive evaluation studies the under-utilized tubers consumed by the tribals *Palliyars* were found to be good sources of protein, lipid, crude fibre, starch, minerals and vitamins. The presence of anti-nutritional factors such as total free phenols, tannins and hydrogen cyanide in the tubers studied can be eliminated by heating or cooking.

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Table. 4. Anti – nutritional factors of under-utilized tubers [a]

Name	Total Free Phenols ($g/100g^{-1}$)	Tannins ($g100g^{-1}$)	Hydrogen cyanide ($mg100g^{-1}$)
Asparagus racemosus	0.28±0.07	0.31±0.09	0.13±0.01
Curculigo orchioides	0.39±0.08	0.08±0.03	0.33±0.09
Dioscorea bulbifera var.*vera*	3.37±0.15	2.55±0.07	0.17±0.02
Dioscorea oppositifolia var. *dukhumensis*	0.24±0.06	0.09±0.02	0.09±0.01
Dioscorea oppositifolia var. *oppositifolia*	0.34±0.03	0.02±0.01	0.30±0.02
Dioscorea pentaphylla var. *pentaphylla*	0.31±0.04	0.06±0.02	0.17±0.05
Dioscorea tomentosa	0.04±0.01	0.20±0.05	0.10±0.01
Dolichos trilobus	0.08±0.03	0.12±0.03	0.32±0.04

[a] all values are means of three determinations expressed in dry weight basis.
± denotes standard error.

REFERENCES

Adelusi, A.A, and Ogundana, S.K 1987. Phenolics and ascorbic acid accumulation in some infected root crops. Journal of Root Crops. 13:29-33.

Akissoe, H.N, Hounhouigan, D.J, Bricas, N, Vernier, P, Nago C.M, and Olorunda, O.A. 2001. Physical, chemical and sensory evaluation of dried yam *(Dioscorea rotundata)* tubers, flour and 'amala', a flour- derived product. Tropical Science. 41:151-155.

Alozie, Y, Akpanabiatu, M.I, Eyong, E.U, Umoh, L.B, and Alozie, G. 2009. Aminoacid composition of *Dioscorea dumetorum* varieties. Pakistan Journal of Nutrition. 8: 103-105.

Amubode, F.O, and Fetuga, B.L. 1983. Proximate composition and chemical assay of methionine, lysine, tryptophan in some Nigerian forest trees. Food Chemistry. 12: 67-72.

AOAC 1970. 0fficial Methods of Analysis (11 th edn.) Association of Official Analytical Chemists, Washington.DC.

Arinathan, V. 2007. Wild edibles used by *Palliyars* of the Western Ghats, Tamil Nadu. Indian Journal of Traditional Knowledge.6: 163-168.

Babu, L, Nambisan, B, and Sundaresan, S. 1990. Comparative evaluation of biochemical constituents of selected tuber crops. Journal of Root Crops. 17: 270-273.

Balagopalan, C. 2000. Integrated technologies for value addition and post harvest management in tropical tuber crops. Central Tubers Crops Research Institute. Kerala, India

Burns, R.R. 1971. Methods for estimation of tannin in grain Sorghum. Agronomy Journal. 63:511-512.

Dickman, S.R, and Bray, R.H. 1940. Colorimetric determination of phosphate. Industrial and Engineering Chemistry, Analytical Education, 12:665-668.

Gopalan, C, Ramashastri, B.V, and Balasubramanian, S.C. 1976. Nutritive value of Indian Foods. I.C.M.R., New Delhi.

Haq, N. 1983. New food legume crop for the tropics. In: Better crops for food Eds. N.Nugent and M.O. Conor . Pitman Books, London (Cuba Foundation Symposium 97) pp. 144-160.

Hill, M.S. 1984. Seed Technology Training and Research in Southeast Asian Countries. Food and Fertilizer Technology Centre (ASPAC) Extension Bulletin No. 207:1-6.

Humphries, E.C. 1956. Mineral components and ash analysis. In: Modern Methods of Plant Analysis. Vol.1. Edn. K. Paech and M.V. Tracey. M.V. Springer-Verlag, Berlin, pp:468-502.

Issac, R.A, and Johnson, W.C. 1975. Collaborative study of wet and dry ashing techniques for the elemental analysis of plant tissues by Atomic Absorption Spectrophotometer. Journal of Association of Official Analytical Chemists, 58:436-440.

Jackson, M.L. 1967. Cyanide in plant tissue. In: Soil Chemical Analysis. Asia Publishing House, New Delhi, India. pp.337.

Janardhanan, K. 1990. Germplasm resources of pulses of tribal utility in India. In: Proceedings of the National Seminar on Advances in Seed Science and Technology Eds. H.S. Shetty, and H.S. Prakash. December 14-16, 1989. University of Mysore, India. pp.407-409.

Kataria, A, Chauhan, B.M, and Punia, D. 1989. Anti-nutrients and protein digestibility (*in vitro*) of mung bean as affected by domestic processing and cooking. Plant Foods for Human Nutrition. 3:9-17.

Muller, H.G, and Tobin, G. 1980. Nutrition and Food processing. Crom Helm Ltd., London.

Murugesan, P.T, and Ananthalakshmi, A. 1991. Dietary practices of the *Palliyar* tribal group and the nutrient content of unconventional foods consumed. Indian Journal of Nutrition and Dietetis. 28:297-301.

Nair, D.B, and Nair, V.M. 1992. Nutritional studies in sweet potato. Journal of Root Crops. 18: 53-57.

Nambisan, B, and Sundaresan, S. 1990. Distribution pattern of cyanoglucosides in cassava tubers and leaves at different growth stages. Journal of Root Crops. 17: 261-264.

NAS 1979. Tropical legumes resources for the future. National Academy of Sciences. Washington DC.

NRC/NAS 1980. National Research Council Committee on Dietary Allowances. Recommended Dietary Allowances. 9th edn. National Academy of Science Press, Washington DC, USA.

NRC/NAS 1989. National Research Council Committee on Dietary Allowances. Recommended Dietary Allowances. 10th edn. National Academy of Science Press, Washington DC, USA.

Oke, O.l. 1969. The role of hydrocyanic acid in nutrition. World Review of Nutrition and Dietetis. 11:118-174.

Oke, O.L. 1975. The role of cassava in the nutrition of Nigerian population. Journal of Root Crops. 1:1-15.

Onyilagha, J.C, and Lowe, J. 1985. Crude proteins of some Nigerian cultivars of *Dioscorea cayenensis* and *D. rotundata.* Journal of Root Crops. 11:61-63.

Padmaja, G, Moorthy, S.N, Nambisan, B, Babu, L, Sundaresan, S, Sajeev, M.S, Nanda, S.K, Susan John, K, Rajalekshmy, L, Sudha Devi, K.S. and Manikantan Nair, M. 2005. Digestibility of Starch and Protein. In: Analytical Methodologies for Tropical Tuber Crops. Eds: Central Tuber Crops Research Institute, Kerala, pp.34-38.

Pramila, S.S, Kumar, A. and Raghuvanshi, R. 1991. Nutrient composition of some uncommon foods consumed by Kumaon and Garhwal hill subjects. Journal of Food Science and Technology. 28:237-238.

Rajyalakshmi, P. and Geervani, P. 1994. Nutritive value of the foods cultivated and consumed by the tribals of South India. Plant Foods for Human Nutrition. 46:53-61.

Robinson, D.R. 1987. Food biochemistry and nutritional value. Longman Scientific and Technol, Burnmell, Haslow, England, pp 327-328.

Sadasivam, S. and Manickam, A. (eds) 1996. In: Biochemical methods, New Age International (P) Limited Publishers, New Delhi, India, pp 1-250.

Shanthakumari, S, Mohan, V.R, and de Britto, J. 2008. Nutritional evaluation and elimination of toxic principles in wild yam (*Dioscorea* spp.). Tropical and Subtropical Agroecosystems. 8: 313-319.

Siddhuraju, P. Vijayakumari, K. and Janardhanan, K. 1996. Chemical composition and protein quality of the little-known legume, velvet bean (*Mucuna pruriens* L. DC.) Journal of Agricultural and Food Chemistry. 44: 2636-2641.

Singh, U. 1988. Anti-nutritional factors of chickpea and pigeonpea and their removal by processing. Plant Foods for Human Nutrition 38: 251-261.

Singh,U. and Singh, B. 1992. Tropical grain legume as important human foods. Economic Botany. 46:310-361.

Sundaresan, S, Babu, L, and Nambisan, B. 1990. Biochemcial changes in yam tubers during storage. Journal of Root Crops 17:265-269.

Udensi, E.A, Oselebe, H.O, and Iweala, O.O. 2008. The investigation of chemical composition and functional properties of water yam (*Dioscorea alata*): Effect of varietal differences. Pakistan Journal of Nutrition. 7: 342-344.

Udoessien, E.I, and Ifon, E.T. 1992. Chemical evaluation of some anti nutritional constituents in four species of yam. Tropical Science. 32:115-119.

Uzogara, S.G, Morton, I.D, and Daniel, J.W. 1990. Changes in some anti nutrients of cowpeas *(Vigna unguiculta)* processed with 'Kanwa' alkaline salt. Plant Foods for HumanNutrition.40:249-25

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