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Nutrient Contents and Antinutritional Factors in Conventional and Non-conventional Leafy Vegetables

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ABSTRACT

Tender green leaves of conventional and non-conventional vegetables were evaluated for nutritional and anti-nutritional factors, which depict their quality. Crude protein, ether extractives and ash varied from 15·7 to 28·5, 1·0 to 6·5 and 9·2 to 20·4% respectively. Amaranthus flavus *(amaranth),* Colocasia esculenta *(colocasia),* Moringa oleifera *(drumstick),* Trigonella foenum graecum *(fenugreek),* Azadirachta indica *(Neem) and* Telfaria occidentalis *(Pumpkin) are good sources of neutral detergent fibre (NDF), and acid detergent fibre (ADF). These vegetables are found to be rich sources of macro and micro elements. Calcium, phosphorus and zinc varied from 0·9 to 2·9, 0·4 to 1·2% and 17·5 to 46·2 ppm, respectively. Drumstick contained the maximum amount of flatus factors (Sucrose + raffinose + stachyose) (5·6%) followed by neem (3·2%) and colocasia (2·2%). Amaranth had the maximum amount of nitrate, oxalate, trypsin inhibitor and phytate. Variable amounts of amino acids were present in these vegetables. Protein was found to be positively correlated with NDF, Cu, Fe, Zn and Mn; and negatively correlated with ADF, NDF, phytate, phenol and saponin contents. Saponin was found to be positively correlated with sugar, Fe and Zn contents. Phytate is negatively correlated with saponin, Cu, Zn, NDF and ADF but positively correlated with phenol.*

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INTRODUCTION

India, being blessed with a variety of natural surroundings and varying climates and seasons, has a number of species of edible leafy vegetables, some of which do not have English names and are known only by local names. Some of the common leafy vegetables are amaranth, cabbage, coriander, fenugreek, spinach, etc. Indian households include a leafy vegetable preparation in their daily diet. These green leafy vegetables are inexpensive, easily and quickly cooked and rich in several nutrients such as vitamins, minerals, protein, etc. (Oke, 1966; Gopalan *et al.*, 1971). In summer when natural succulent fodders are scarce, neem leaves are used as fodder for cattle, which are rich in crude protein, calcium and phosphorus contents (Patel & Patel, 1957; Patel *et al.*, 1962; Jayal, 1963; Ketkar, 1976). The main problem in nutritional exploitation of green leafy vegetables is the presence of antinutritional and toxic principles. Leafy vegetables, such as amaranth, chenopodium, lettuce, spinach, etc., accumulate high concentrations of nitrate, oxalate and saponin (Pedersen & Wang, 1971; Cheeke & Bronson, 1980; Fenwick & Oakenfull, 1983). Recently, a search for lesser known leafy crops, many of which are potentially valuable as human and animal food/feed has been made to maintain a balance between population growth and agricultural productivity, particularly in the tropical and subtropical areas of the world. Presence of a large number of inexpensive edible green leafy vegetables, their abundance and their attributive qualities, creates an interest in the study of nutritional value and antinutritional factors of some of the selected conventional and non-conventional green leafy vegetables; namely, amaranth, colocasia, drumstick, fenugreek, neem and pumpkin.

MATERIALS AND METHODS

Fresh, tender, green leaves of conventional—amaranth (*Amaranthus flavus*), colocasia (*Colocasia esculenta*), fenugreek (*Trigonella foenumgraecum*)—and non-conventional—drumstick (*Moringa oleifera*), neem (*Azadirachta indica*), Pumpkin (*Telfaria occidentalis*)—vegetables were obtained from the local market and local places of Delhi, washed under running water, shade-dried and finally sun-dried. The samples were finely powdered and stored in airtight and coloured glass containers for further analysis. Crude protein (CP), ether extractives (EE, fat) and ash (minerals) were estimated by the standard methods of AOAC (1970). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemi-cellulose (HC) were determined according to Goering & Van Soest (1970). Calcium, magnesium and phosphorus were estimated by the colorimetric methods of Trinder (1960), Neill & Neely

(1956) and Fiske & Subharow (1925), respectively. Sodium and potassium were estimated using flame photometry after digesting the sample with triacid mixture (Nitric acid:Perchloric acid:Sulphuric acid 4·0:0·5:0·5 v/v). Iron, zinc, copper and manganese were estimated by the atomic absorption spectrophotometric method in triacid hydrolysate. These samples were also analysed for total soluble sugars (Clegg, 1956), reducing sugars (Nelson, 1944) and flatulence factors, viz. sucrose, raffinose and stachyose. These were extracted using 80% aqueous ethanol (Williams, 1984) and separated from ethanolic extract with thin-layer chromatography using silica gel G and *n*-propanol:ethylacetate:water (6:3:1 v/v) as the developing solvent (Tanaka *et al.*, 1975). They were detected using α-naphthol in concentrated sulphuric acid (Bailey & Pridham, 1962) and finally determined quantitatively (Dubois *et al.*, 1956).

Nitrate was extracted (Grover *et al.*, 1978), reduced (Downes, 1978) and finally estimated colorimetrically (Snell & Snell, 1949). Oxalate and saponin were estimated by the method of AOAC (1970) and Gestetner *et al.* (1966), respectively. Trypsin inhibitor activity and soluble proteins were estimated according to Kakade *et al.* (1969) and Lowry *et al.* (1951), respectively. Phenol was quantitated according to Swain & Hillis (1959) and phytate estimated by the method of Davies & Reid (1979). Amino acids were determined in acid hydrolysate by Beckman Automatic Amino Acid Analyser, using authentic standard amino acids. Tryptophan and methionine were estimated by the method of Spies & Chambers (1949) and Horn *et al.* (1946), respectively.

The data were analysed statistically with CRD and correlation was also worked out (Gupta, 1973).

RESULTS AND DISCUSSION

Proximate principles and structural carbohydrates (neutral detergent fibre, acid detergent fibre, hemicellulose) in conventional and non-conventional leafy vegetables are reported in Table 1. Protein content in amaranth, drumstick, fenugreek and pumpkin varied from 25·1 to 28·5%, while in colocasia (18·0%) and neem (15·7%) it was in the lower range. Hussain *et al.* (1984) reported the crude protein in colocasia cormel (10·4%). Ether extractives and total ash varied from 1·0% (pumpkin) to 6·5% (drumstick) and 9·2% (neem) to 20·4% (amaranth), respectively. Pumpkin had the highest amount of NDF and ADF, while the fenugreek had the least amount of NDF. Amaranth had the maximum amount of hemicellulose and fenugreek the least. These green leafy vegetables (conventional and non-conventional) are rich sources of minerals and structural carbohydrates.

TABLE 1

Proximate Principles in Conventional and Non-conventional Leafy Vegetables

Chemical constituents	*Leafy vegetables*						*F. values*	*Significance at 1%*
	Amaranth	*Colocasia*	*Drumstick*	*Fenugreek*	*Neem*	*Pumpkin*		
Crude protein (%)	25·1	18·0	26·4	28·5	15·7	25·6	18	**
Ether extractives (%)	1·2	4·0	6·5	4·0	2·7	1·0	3 069	**
Total ash (%)	20·4	10·6	12·0	9·8	9·2	19·2	2 635	**
Soluble ash (%)	16·5	10·4	11·4	9·3	8·6	16·1	2 494	**
NDF (%)	42·6	37·0	28·8	21·2	38·2	44·2	65 562	**
ADF (%)	21·0	21·7	13·9	19·9	26·8	33·3	39 100	**
HC (%)	21·6	15·3	14·9	1·3	17·4	10·9	51 770	**

NDF: Neutral detergent fibre.
ADF: Acid detergent fibre.
HC: Hemicellulose.
F value at 5% level of significance: 5·06.
F value at 1% level of significance: 3·11.
** Highly significant.

Gopalan *et al.* (1971) and Oke (1966) reported variation of ether extract in amaranth tender (0·5 to 2·69%), while Patel *et al.* (1962), Ketkar (1976) and Jayal (1963) reported a variation in ether extract in neem (2·31 to 6·93%) collected from different places and at different seasons.

Calcium, phosphorus and magnesium among these vegetables varied from 0·9 to 2·9, 0·4 to 1·2 and 0·3 to 1·0%, respectively (Table 2). Fenugreek had the highest amount of sodium, while amaranth had the highest amount of potassium. Pumpkin contained the maximum amounts of copper and zinc, while colocasia had the lowest amounts of copper and zinc. The variations in proximate principles and minerals among these vegetables are highly significant. Amaranth contained good amounts of calcium, phosphorus, magnesium, potassium, iron and manganese. On the other hand, fenugreek was a poor source for calcium, phosphorus and magnesium. The mineral contents recorded in the present study are comparable to the findings of other workers (Singh *et al.*, 1969; Gopalan *et al.*, 1971; Ifon & Bassir, 1979; Hill & Rawate, 1982). Variation in chemical constituents may be due to a species difference and different agroclimatic conditions. The variation may be due to different age and stage of the plants. Protein content is positively correlated with Cu, Fe, Zn, Mn but negatively correlated with ADF, NDF, phytate, phenol and saponin contents (Table 5). ADF and NDF were also negatively correlated with phytate and phenol contents. Green leafy vegetables are rich sources of protein and minerals and fibres.

Total sugars and flatus factors are reported in Table 3. Amongst the different leafy vegetables analysed, drumsticks had the maximum amount of sucrose, raffinose and stachyose. Next in order was neem and amaranth had the least amount of raffinose and stachyose. Total sugar amongst these vegetables varied from 3·7% (pumpkin) to 13·0% (neem). It is well known that legumes cause flatulence due to the presence of sugars like raffinose and stachyose in high concentrations (Tanaka *et al.*, 1975; Gupta & Wagle, 1978, 1980). However, in the leafy material the concentration of the flatulence factors is markedly low. Sugar was found to be positively correlated with saponin content (Table 5). Amaranth had the highest amount of nitrate, oxalate and antitrypic units (Table 4), while neem contained the maximum amount of saponin; fenugreek had the maximum amount of phenol and colocasia had the maximum amount of phytate. A significant variation was observed in antinutritional factors amongst these vegetables. No report is available on flatus factors in leafy vegetables. Reddy *et al.* (1982) reported higher amounts of phytate in cereals and pulses (0·5% to 6·0%) and phytate adversely affected the bioavailability of minerals, Mg, Cu, Zn, etc. (Nolan & Duffin, 1987). Similar results with respect to oxalate content in all leafy vegetables have been reported (Oke, 1966; Hussain *et al.*, 1984; Teutonico & Knorr, 1985). Satoh *et al.* (1985) reported the presence of trypsin inhibitor in

TABLE 2
Minerals in Conventional and Non-conventional Leafy Vegetables

Chemical constituents	*Leafy vegetables*						*F. values*	*Significance at 1%*
	Amaranth	*Colocasia*	*Drumstick*	*Fenugreek*	*Neem*	*Pumpkin*		
Calcium (%)	2·9	1·3	2·4	0·9	2·0	1·9	300	**
Phosphorus (%)	1·1	0·6	0·6	1·0	0·4	1·2	85	**
Magnesium (%)	1·0	0·3	0·3	0·3	0·3	0·3	153	**
Sodium (mg/100 g)	0·14	0·04	0·05	1·03	0·03	0·02	7 435	**
Potassium (mg/100 g)	2·3	1·7	0·3	1·2	0·6	0·3	15 665	**
Copper (ppm)	8·3	8·3	11·7	25·0	16·7	25·00	6 013	**
Iron (ppm)	712·5	100·0	225·0	312·5	262·5	350·00	1 675	**
Zinc (ppm)	37·5	17·5	17·5	27·5	22·5	46·25	1 713	**
Manganese (ppm)	62·5	43·7	50·2	37·5	34·5	25·00	42 065	**

TABLE 3
Flatus Factors in Conventional and Non-conventional Leafy Vegetables

Chemical constituents	*Leafy vegetables*						*F. values*	*Significance at 1%*
	Amaranth	*Colocasia*	*Drumstick*	*Fenugreek*	*Neem*	*Pumpkin*		
Total sugar (%)	5·6	8·6	12·0	8·1	13·0	3·7	9 227	**
Sucrose(S) (%)	0·8	1·4	2·2	0·5	1·7	0·4	1 653	**
Raffinose (R) (%)	0·2	0·2	2·1	0·2	0·8	0·2	5 958	**
Stachyose (St) (%)	0·2	0·5	1·3	0·2	0·7	0·3	6 092	**
S + R + St	1·2	2·2	5·6	1·0	3·2	0·9	171 010	**

TABLE 4
Antinutritional Factors in Conventional and Non-conventional Leafy Vegetables

Chemical constituents	*Leafy vegetables*						*F. values*	*Significance at 1%*
	Amaranth	*Colocasia*	*Drumstick*	*Fenugreek*	*Neem*	*Pumpkin*		
Nitrate (mmole/100 g)	56·9	0·3	0·5	1·6	0·1	9·3	153 180	**
Oxalate (%)	7·9	5·1	4·1	4·6	2·9	2·8	276	**
Saponin (%)	1·9	0·9	1·2	1·7	3·1	1·9	46	**
Anti-tryptic activity (TIU/mg protein)	8·1	3·3	N.D.	6·0	1·0	4·5	460	**
Phenol (mg tannic acid equivalent/g dry wt)	11·0	36·0	27·3	53·4	36·5	11·8	17 901	**
Phytate (mg/g)	32·9	32·5	31·1	32·1	31·6	5·2	15 779	**

TABLE 5
Correlation Matrix for Different Chemical Constituents of Leafy Vegetables

	ADF	*Phytate*	*Phenol*	*Saponin*	*Cu*	*Fe*	*Zn*	*Mn*	*NDF*	*Protein*
ADF	1·0000	−0·7677	−0·3383	0·5079	0·5162	0·0713	0·6751	−0·7115	0·6513	−0·2712
Phytate	−0·7677	1·0000	0·5143	−0·0812	−0·5929	−0·0245	−0·7397	0·6626	−0·4724	−0·2304
Phenol	−0·3383	0·5143	1·000	−0·0181	0·2579	−0·5675	−0·6289	−0·2297	−0·8191	−0·1076
Saponin	0·5079	−0·0812	−0·0181	1·0000	0·3327	0·2904	0·2657	−0·3109	0·2714	−0·3574
Cu	0·5162	−0·5929	−0·2579	0·3327	1·0000	−0·0923	0·4665	0·8000	−0·2528	0·3837
Fe	0·0713	−0·0245	−0·5675	0·2904	−0·0923	1·0000	0·6554	0·5022	0·3639	0·3884
Zn	0·6751	−0·7397	−0·6289	0·2657	0·4665	0·6554	1·0000	−0·2332	0·5364	0·4121
Mn	−0·7115	0·6626	−0·2297	−0·3109	−0·8000	0·5022	−0·2332	1·0000	−0·0186	0·1424
NDF	0·6513	−0·4724	−0·8191	0·2714	−0·2528	0·3639	0·5364	−0·0186	1·0000	−0·4018
Protein	−0·2712	−0·2304	−0·1076	−0·3574	0·3837	0·3884	0·4121	0·1424	−0·4018	1·0000

Correlation matrix

	Sugar	Saponin
Sugar	1·0000	0·2103
Saponin	0·2103	1·0000

TABLE 6
Amino Acid Composition (g/16 gN)

a-a	*Amaranth*	*Colocasia*	*Drumstick*	*Fenugreek*	*Neem*	*Pumpkin*
ASP + ASn	1·41	13·1	14·5	21·9	20·4	13·7
Thr	0·462	4·92	3·51	2·66	6·2	2·32
Ser	1·08	5·95	6·26	5·31	10·3	2·49
Glu + Gln	1·75	9·13	14·0	10·7	13·48	12·9
Pro	0·965	1·41	10·9	5·41	8·74	3·91
Gly	0·953	8·08	5·59	3·28	8·20	4·89
Ala	0·742	9·32	9·42	4·72	11·9	6·45
Val	0·659	11·8	8·71	5·52	12·6	8·60
Cys	0·640	—	—	—	0·450	0·060
Met	0·112	0·096	0·081	0·090	0·130	0·110
Ilc	0·899	17·1	12·8	8·86	13·1	7·61
Leu	0·598	2·77	6·29	6·76	4·12	5·36
Tyr	0·304	1·069	—	—	—	0·310
Phe	0·288	0·270	0·290	0·302	0·120	0·210
Lys	0·920	3·62	4·89	4·22	5·70	3·78
His	1·36	0·799	1·77	1·00	0·740	0·684
Arg	3·84	6·25	5·76	3·08	4·18	3·53
Try	1·12	0·096	0·104	0·142	0·080	0·800

spinach leaves. Variable amounts of amino acids in leafy vegetables have been observed (Table 6). Our results are in good agreement with the report of Gopalan *et al.* (1971). Green leafy vegetables are deficient in sulphur amino acids.

It would thus appear that a systematic study on the flatus producing factors, toxic and antinutritional attributes in conventional and non-conventional green leafy vegetables is essential for their nutritional evaluation.

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