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Nutritional and Antinutritional Factors of Green Leafy Vegetables

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On a moisture-free basis, mustard had the maximum crude protein (CP 29.82%), while spinach had the minimum CP (21.59%). Lipid content varied from 1.17 (spinach) to 3.73% (cauliflower). Crude fiber and total minerals varied from 7.20 to 13.95% and 12.54 to 26.16%, respectively. Chickpea had the highest amount of iron, copper, manganese, and calcium. Mustard had the maximum amount of phosphorus (1210.0 mg %) while spinach had the minimum amount (740.0 mg %). The maximum amounts of nitrate (5.35556%), saponin (2.45%), and oxalate (8.69%) were noted in spinach. No tryptic activity was detected in chickpea. A wide variation in amino acid profile was observed among green leafy vegetables. Green vegetables are good sources of minerals.

Leafy vegetable preparations include the raw salad, widely known all over the world, in partially or completely cooked or fried forms. Indian cuisine has a wide range of choice among the leafy vegetables. In most Indian households, the inclusion of a leafy vegetable preparation in daily diet is an accepted practice. These green leafy vegetables are inexpensive, are easily and quickly cooked, and are rich in several nutrients such as vitamins, minerals, proteins, etc. (Oke, 1966; Gopalan et al., 1971). Sigh et al. (1969) and Cheeke and Bronson (1980) have reported that green leaves are a good source of available calcium. The main problem in nutritional exploitation of green leafy vegetables is the presence of antinutritional and toxic principles. Amaranth, chenopodium, lettuce, spinach, etc., accumulate high concentrations of nitrate, oxalate, and saponin (Cheeke and Bronson, 1980; Olson et al., 1972; Pedersen and Wang, 1971; Fenwick and Oakenfull, 1983). Amaranth leaves were shown to be a potential plant source of nitrate and oxalate (Carlsson, 1975; Marshall et al., 1967; Teutonico and Knorr, 1985), and their nitrate content could reach 3.25%, causing fatal methemoglobinamea in cattle (Steyn, 1960; Clarke and Clarke, 1967; Fowler, 1967; Buck et al., 1973). Nitrate poisoning by amaranth was reported in livestock (Whitehead and Moxon, 1949). Reduced levels of vitamin A in liver, fatty degeneration of liver cells, and follicular atrophy were observed in rats fed amaranth dye (Galea et al., 1971; Shtenberg and Gavrilenko, 1972). Several authors have also indicated the presence of a specific trypsin inhibitor in alfalfa leaves (Kendall, 1951; Ramirej and Mitchell, 1960; Chang, et al., 1978). Kohler and Bickoff (1970) reported that green leaves were rich in protein, but their utilization was limited because of the presence of indigestible fiber. The presence of a large number of inexpensive edible green leafy vegetables, their abundance, and their attributive qualities create interest to study the nutritional value of selected green leafy vegetables.

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Table I. Proximate Principles of Green Leafy Vegetables (Percent Dry-Weight Basis)[a]

vegetable	crude protein	ether extractive	crude fiber	minerals (ash)	sol ash
chickpea	22.61	1.30	13.95	14.55	11.87
chenopodium	28.60	2.55	7.20	21.05	20.41
spinach	21.59	1.17	9.61	26.16	24.84
mustard	29.82	1.68	11.99	17.49	15.85
cauliflower	23.65	3.73	9.23	12.54	11.94
F values	56.99	24.68	38.31	116.90	96.75

[a] Each value is the average of triplicate determinations

METHODS AND MATERIALS

Green leafy vegetables, viz. cauliflower (*Brassica oleracea*), chenopodium (*Chenopodium album*), chickpea (*Cicer arietinum*), mustard (*Brassica compestris*), and spinach (*Spinacea oleracea*), were collected from the Haryana Agricultural University Farm, washed under running tap water, sun-dried, ground to pass a 100-mesh sieve, and stored in colored air-tight containers until further analysis. Crude protein (CP), ether extractives (EE, lipid), crude fiber (CF), and ash (minerals) were estimated by the standard methods of the AOAC (1970). Calcium, magnesium, and phosphorus were estimated by the colorimetric methods of Trinder (1960), Neill and Neely (1956), and Fiske and Subharow (1925), respectively. Sodium and potassium were estimated by flame photometry after the sample was digested with a triacid mixture

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Table II. Mineral Contents of Green Leafy Vegetables (mg/100 g)[a]

vegetable	Cu	Fe	Zn	Mn	Na	K	Mg	Ca	P
chickpea	1.667	72.50	2.250	14.062	23.00	58.50	280.0	2960.0	890.0
chenopodium	1.667	26.25	3.250	8.125	529.00	3802.50	1010.0	1840.0	960.0
spinach	0.833	35.00	4.250	8.750	3818.00	1170.0	770.0	870.0	740.0
mustard	1.250	45.00	3.875	4.375	690.00	2047.50	310.0	2050.0	1210.0
cauliflower	1.667	25.00	2.250	4.687	437.00	585.00	250.0	2310.0	810.0
F values	348.09	1055.90	2522.20	0.86	2081.75	986.38	1198.36	168.88	122.84

[a] Each value is the average of triplicate determinations.

Table III. Antinutritional Factors in Green Leafy Vegetables[a]

vegetable	nitrate, %	saponin, %	oxalate, %	TIU/mg of protein
chickpea	0.00744	1.60	4.64	nd[b]
chenopodium	0.53320	0.90	8.49	0.91
spinach	5.35556	2.45	8.69	2.46
mustard	0.64976	0.46	3.12	2.06
cauliflower	0.02356	2.40	2.67	3.61
F values	77892.5	17.18	31.52	17.86

[a] Each value is the average of triplicate determinations. [b] nd = not detected.

(nitric acid–perchloric acid–sulfuric acid, 4:0.5:0.5, v/v). Iron, zinc, copper, and manganese were estimated by atomic absorption spectrophotometric methods in triacid hydrolysate.

Nitrate was extracted (Grover et al., 1978), reduced (Downes, 1978), and finally estimated colorimetrically (Snell and Snell, 1949). Oxalate and saponin were estimated by the methods of the AOAC (1970) and Gestetner et al. (1966), respectively. Trypsin inhibitor units and soluble proteins were estimated according to Kakade et al. (1969) and Lowry et al. (1951), respectively. For amino acid determination, samples were hydrolyzed in 6 N hydrochloric acid in sealed tubes. Before hydrolysis, samples were treated with nitrogen, and during sealing of the tubes, a nitrogen stream was used to diminish the destruction of amino acids during hydrolysis. The amino acids were then determined by an automatic amino acid analyzer, using authentic standard amino acids. The data were analyzed statistically with CRD.

RESULTS AND DISCUSSION

Data on proximate principles of green leafy vegetables are given in Table I. Crude protein and ether extractives (lipid) in leafy vegetables ranged from 21.59 (spinach) to 29.82% (mustard) and 1.17 (spinach) to 3.73% (cauliflower), respectively. Chickpea contained the maximum amount of crude fiber (13.95%) whereas chenopodium contained the smallest amount (7.20%). Spinach contained the maximum amount of total ash and soluble ash (26.16 and 24.84%, respectively) while a minimum value (12.54%) was observed in cauliflower. Variations among different vegetables are highly significant. The results of the present investigation are in good agrement with the reports of Livingston et al. (1972), Patel and Patel (1957), and Hill and Rawate (1982). Green leafy vegetables are rich sources of protein and minerals, but their utilization is limited due to the presence of indigestible fiber (Kohler and Bickoff, 1970).

Calcium and phosphorus contents are maximum in chickpea and mustard, respectively, while these nutrients are minimum in spinach (Table II). Chickpea contained the highest amounts of copper, iron, and manganese in comparison to other leafy vegetables. All values of minerals are highly significant among vegetables, except manganese content, which is not significantly different. Similar results were reported by several authors (Singh et al., 1969; Ifon and Bassir, 1979; Cheeke and Bronson, 1980; Livingston et al., 1972).

Nitrate, oxalate, saponin, and trypsin inhibitor units are reported in Table III. Nitrate, oxalate, and saponin contents varied from 0.007 44 (chickpea) to 5.355 56% (spinach), 2.67 (cauliflower) to 8.69% (spinach), and 0.46 (mustard) to 2.45% (spinach), respectively. Spinach had the maximum amounts of nitrate, oxalate, and saponin. Cauliflower showed the highest antitryptic activity (3.61 TIU/mg of protein), followed by spinach (2.46 TIU/mg of protein) and mustard (2.06 TIU/mg of protein). There was no trypsin inhibitor activity in chickpea. The differences in these antinutritional factors among different vegetables are highly significant. Nitrate levels in spinach and oxalate in chenopodium ranged from 0.086 to 0.316% and 3.04 to 8.20%, respectively (Okiei and Adamson, 1979; Lee et al., 1971; Singh and Saxena, 1972; Singh et al., 1973; Carlsson, 1975; Teutonico and Knorr, 1985). Oxalate and nitrate contents in these green leafy vegetables are in good agreement with the reports of these authors. The degree of accumulation of antinutritional factors is primarily related to species, the plant part, age of the plant, and the amount of nitrate in the growing medium (Donald and MacDonald, 1978). In the present investigation, the presence of saponin and trypsin inhibitors has been identified in these green leafy vegetables.

Amino acid compositions from different green leafy vegetables are recorded in Table IV. Mustard contained the highest amount of aspartic acid + asparagine (13.593 g/16 g of N), valine (17.927 g/16 g of N), isoleucine (16.603 g/16 g of N), and lysine (3.219 g/16 g of N), while spinach contained the smallest amounts of aspartic acid, valine, and isoleucine. Methionine and cystine could not be detected in any of the green leafy vegetables. Either they are destroyed during the processing or the amount present is so low as to be not detectable. Chickpea had the lowest amount of phenylalanine (0.013 g/16 g of N), while chenopodium had the maximum amount of phenylalanine (0.279 g/16 g of N). Cauliflower had the maximum amount of histidine. Different amino acid levels depict the quality of leafy vegetables. It is valuable to determine these chemical constituents and antinutritional factors in any

Table IV. Amino Acid Contents of Green Leafy Vegetables (g/16 g of N)[a]

vegetable	Asp + Asn	Thr	Ser	Glu, Gln	Pro	Gly	Ala	Val	Ile	Leu	Tyr	Phe	Lys	His
chickpea	10.730	2.926	3.665	5.243	2.096	2.583	2.404	4.970	4.848	2.930	0.813	0.013	3.070	0.809
chenopodium	4.248	2.203	2.902	7.045	1.972	3.444	3.031	2.996	4.412	2.825	0.297	0.297	0.307	0.286
spinach	2.745	0.265	0.891	4.266	2.014	1.798	1.806	2.051	3.118	1.850	0.177	0.152	1.986	0.285
mustard	13.593	6.381	5.980	6.272	8.301	8.079	6.407	17.921	16.603	0.626	tr	0.116	3.219	0.338
cauliflower	8.368	1.685	3.883	18.692	16.993	2.323	3.703	5.200	4.984	5.128	tr	tr	2.984	2.539

[a] Each value is the average of duplicate determinations.

food consumed by human beings.

Registry No. Cu, 7440-50-8; Fe, 7439-89-6; Zn, 7440-66-6; Mn, 7439-96-5; Na, 7440-23-5; K, 7440-09-7; Mg, 7439-95-4; Ca, 7440-70-2; P, 7723-14-0; NO_3^-, 14797-55-8; oxalic acid, 144-62-7.

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