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Nutritional composition of selected green leafy vegetables, herbs and carrots**

G. SINGH, ASHA KAWATRA* and S. SEHGAL
Department of Foods & Nutrition, CCS Haryana Agricultural University, Hisar – 125 004, India (**author for correspondence*)

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Abstract. Six green leafy vegetables and herbs – spinach, amaranth, bengal gram, cauliflower, mint, coriander and carrots – were analyzed for moisture, protein, ascorbic acid, β-carotene, total iron, ionizable iron (as % of total iron) in vitro iron (% of total iron), copper, manganese and zinc. Moisture content of the leaves and carrots varied from 75.1 percent (bengal gram) to 95.4 percent (carrot) and protein from 9.83 percent (carrots) to 30.9 (mint) percent. Ascorbic acid, β-carotene, total iron and ionizable iron contents were at a maximum in case of bengal gram leaves whereas level of ionizable iron and in vitro iron as a percent of total iron was highest in carrots. Copper, manganese and zinc contents were maximum in spinach.

Key words: β-carotene, Blanching, Carrots, Green leafy vegetables, Herbs, In vitro iron, Ionizable Iron

Introduction

Green leafy vegetables are rich in carotenoids (vitamins) as well as in iron, calcium, ascorbic acid, riboflavin, folic acid and appreciable amounts of other minerals [1, 2]. Vegetables occupy an important place in the vegetarian diets of India. It has been noted that of the total β-carotene available from all sources in the country, 95 percent is derived from fruits and vegetables and, out of this, 90 percent is contributed by green leafy vegetables (52%) and mangoes (38%). An increased intake of β-carotene rich foods in the daily diet may be preferred to the massive synthetic vitamin A dosage approach and can be one of the strategies for improving nutritional status [3]. India, having a variety of natural surroundings and varying climates and seasons, has a number of species of edible leafy vegetables such as spinach, amaranth, bengal gram leaves, cauliflower leaves, mint and coriander. These leafy vegetables and herbs are relatively inexpensive, easily and quickly cooked and rich in several nutrients especially β-carotene and iron which are essential for human health. Carrots are also considered to be a good source of β-carotene

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and are cheap and easily available in the market and can be as useful as green leafy vegetables in supplying β-carotene in the diet. Therefore, this study was conducted to evaluate the nutritional composition of selected green leafy vegetables, herbs and carrots which can contribute sufficient amounts of iron and provitamin A in the diet.

Material and methods

Spinach (*Spinacea oleracea*), amaranth (*Amaranthus tricolor*), mint (*Mentha spicata*), coriander (*Coriandrum sativum*), bengal gram (*Cicer arietinum*) and cauliflower leaves (*Brassica oleracea*) and carrots (*Dacus carota*) were obtained in single lots from the local market of Hisar (Haryana), India. All the selected green leafy vegetables and carrots were nutritionally evaluated for moisture by the method of AOAC [4] and protein by the microKjeldhal method [4]. The ascorbic acid in fresh leaves was estimated by a titration method using indophenol dye [4]. β-carotene content of samples was separated by column chromatography and estimated colorimetrically [4]. Ionizable iron was estimated colorimetrically by using the reagent α-α-diphridyl [4] and in vitro iron was calculated by the equation given by Rao & Prabhavathi [5]

$$Y = 0.4827 + 0.4707X$$

Where Y = % in vitro available iron

X = Ionizable iron

For the determination of total iron, copper, manganese and zinc, about 1.0 g of sample was digested with a diacid mixture (HNO_3:$HClO_4$::5:1, v/v). After complete digestion, each sample was heated to near dryness and volume was brought up to 50 ml with double distilled water. Analysis was done using atomic absorption spectrophotometry (Perkin Elmer, 2380) [6].

Moisture, ascorbic acid and β-carotene were analyzed on a fresh basis; and the rest of the nutrients were estimated on dry matter basis in triplicate.

The leaves of spinach, mint, coriander, cauliflower, amaranth and bengal gram were separated from their stalks and washed under running tap water. Then the leaves were blanched in boiling distilled water for 10–15 s. After that, leaves were spread on filter paper and dried at room temperature for 1–2 h. Then the leaves were dried in an air oven (Yarco, India) at 40+5 °C for 4–6 h. The carrots were washed in distilled water and cleaned thoroughly, peeled by scrapping with a knife, blanched for one minute in boiling water, shredded and dried in an air oven at 50 $\pm$ 5 °C for 16–18 h. The dried leaves as well as carrot shreds were ground to fine powder in a Cyclotec mill of 60 mesh size. The dried powders of green leaves and carrots were nutritionally evaluated for protein, ionizable iron, in vitro iron, copper, manganese and zinc.

Table 1. Moisture, protein, ascorbic acid and β-carotene contents of green leafy vegetables and carrots (fresh weight basis)

	Moisture (%)	Protein* (%)	Ascorbic acid (mg/100 g)	β-carotene (mg/100 g)
Mint	88.2 $\pm$ 0.07[a]	30.9 $\pm$ 0.08[a]	23.9 $\pm$ 0.36[a]	4.3 $\pm$ 0.07[a]
Coriander	86.9 $\pm$ 0.17[b]	22.2 $\pm$ 0.05[b]	98.1 $\pm$ 0.27[b]	6.1 $\pm$ 0.10[b]
Bengal gram	75.1 $\pm$ 0.07[c]	26.2 $\pm$ 0.09[c]	110.4 $\pm$ 1.28[c]	11.8 $\pm$ 0.02[c]
Spinach	94.2 $\pm$ 0.04[d]	26.5 $\pm$ 0.10[c]	36.8 $\pm$ 0.14[d]	4.0 $\pm$ 0.18[a]
Cauliflower	86.8 $\pm$ 0.12[b]	29.9 $\pm$ 0.21[d]	42.4 $\pm$ 0.74[e]	7.2 $\pm$ 0.05[d]
Amaranth	83.5 $\pm$ 0.21[e]	26.2 $\pm$ 0.05[c]	107.7 $\pm$ 0.56[f]	5.4 $\pm$ 0.14[e]
Carrot	95.4 $\pm$ 0.12[f]	9.8 $\pm$ 0.17[e]	4.9 $\pm$ 0.57[g]	2.2 $\pm$ 0.10[f]
CD ($p < 0.05$)	0.38	0.36	1.97	0.32

Values are mean $\pm$ SEM of three replicates.
* Protein content is on dry weight basis.
Figures within the column bearing different superscripts are significantly different.

Statistical analysis. Statistical analysis of data was done using analysis of variance [7]. Critical difference (CD) at $p \leq 0.05$ was estimated.

Results and discussion

The moisture content of vegetables ranged between 75.1 to 95.4 percent (Table 1). Maximum moisture content was found in carrots (95.4%). The moisture content obtained in the leafy vegetables was close to that reported by Islam et al. [8] in spinach (90.6%) and by Nambiar & Seshadri in bengal gram leaves (79.7%) and different species of amaranth leaves (78.5 to 90.0%) [9]. In contrast, lower moisture values in spinach (84.3%) have also been reported [10].

Protein content was highest in mint leaves 30.9% and lowest in carrots (9.8%) on a dry matter basis. Protein contents of coriander, bengal gram, spinach, cauliflower and amaranth leaves were 22.2, 26.2, 26.5, 29.9 and 26.2 percent, respectively (Table 1). Several workers reported a similar value for crude protein in amaranth [11, 12]. Protein content, in the present study, was lower than that reported by Yadav [13] and Islam et al. [8] in spinach leaves i.e., 31.4 and 32.9 percent, respectively. However, Luthra [10] and Gupta & Wagle [14] reported lower values in spinach i.e., 12.1 and 21.6 percent, respectively, when compared with the present study on a dry matter basis. This variation might have been due to differences and variations in agroclimatic conditions.

Ascorbic acid content in leafy vegetables varied from 4.9 to 110.4 mg/100 g (Table 1). Significant ($p < 0.05$) variations were observed in ascorbic acid

Table 2. Total, ionizable and in vitro iron contents of green leafy vegetables and carrots (dry weight basis)

	Total iron (mg/100 g)	Ionizable iron (mg/100 g)	Ionizable Fe (% of total Fe)	In vitro iron (% of total Fe)
Mint	50.6 $\pm$ 0.13^{a}	1.7 $\pm$ 0.04^{a}	3.3 $\pm$ 0.07^{a}	2.0 $\pm$ 0.03^{a}
Coriander	22.3 $\pm$ 0.12^{b}	1.7 $\pm$ 0.10^{a}	7.5 $\pm$ 0.48^{b}	4.0 $\pm$ 0.22^{b}
Bengal gram	84.4 $\pm$ 0.08^{c}	4.6 $\pm$ 0.08^{b}	5.5 $\pm$ 0.10^{c}	3.1 $\pm$ 0.04^{c}
Spinach	35.8 $\pm$ 0.11^{d}	1.7 $\pm$ 0.21^{a}	4.8 $\pm$ 0.58^{c}	2.7 $\pm$ 0.27^{c}
Cauliflower	66.8 $\pm$ 0.09^{e}	2.6 $\pm$ 0.07^{c}	3.9 $\pm$ 0.10^{a}	2.3 $\pm$ 0.05^{a}
Amaranth	26.8 $\pm$ 0.09^{f}	2.0 $\pm$ 0.11^{d}	7.6 $\pm$ 0.42^{b}	4.0 $\pm$ 0.19^{b}
Carrot	7.7 $\pm$ 0.01^{g}	0.6 $\pm$ 0.10^{e}	7.7 $\pm$ 1.36^{b}	4.1 $\pm$ 0.64^{b}
CD ($p < 0.05$)	0.30	0.34	1.84	0.85

Values are mean $\pm$ SEM of three replicates.
Figures within the column bearing different superscripts are significantly different.

content of green leafy vegetables and carrots. Almost similar values for ascorbic acid in amaranth and spinach leaves have been reported earlier. Ascorbic acid contents found in the present study were higher than those reported by some workers in coriander (88.6 mg/100 g) and spinach (25.4 mg/100 g) [16]; and in amaranth leaves (91.0 mg/100 g) [17]. Various reasons including differences in leaf maturity and differences in the ascorbic acid assay employed could account for the differences in ascorbic acid content of leafy vegetables and herbs [18, 19].

β-Carotene content was highest in bengal gram leaves (11.8 mg/100 g) and lowest in carrots (2.2 mg/100 g) on fresh weight basis (Table 1). Significant ($p < 0.05$) differences were observed in all other vegetables and herbs except for mint and spinach. Similar values for β-carotene in spinach and amaranth have been reported [20, 13]. Higher values of β-carotene in spinach (5.10 mg/100 g) have also been reported [21]. β-carotene in fresh bengal gram leaves was found to be 9.70 mg/100 g [9].

Total iron, ionizable iron (amount and percent of total iron), in vitro iron as percentage of total iron are presented in Table 2. Total iron content of selected green leafy vegetables ranged from 22.3 to 84.4 mg/100 g on a dry matter basis. Maximum iron content was found in bengal gram leaves (84.44 mg/100 g) and the minimum was noted in carrots (7.7 mg/100 g). Iron content analyzed in the present study was similar to that reported by Yadav in spinach (35.0 mg/100 g) [13] and lower than that reported by Luthra & Sadana in the same vegetable (54.1 mg/100 g) [10].

Ionizable iron content was maximum in bengal gram leaves (4.6 mg/100 g) and minimum in carrots (0.6 mg/100 g), whereas, ionizable iron, when

Table 3. Copper, manganese and zinc contents of green leafy vegetables and carrots (mg/100 g, dry weight basis)

	Copper	Manganese	Zinc
Mint	1.6 $\pm$ 0.03[a]	5.2 $\pm$ 0.01[a]	4.0 $\pm$ 0.08[a]
Coriander	1.2 $\pm$ 0.03[b]	3.7 $\pm$ 0.04[b]	2.7 $\pm$ 0.05[b]
Bengal gram	1.7 $\pm$ 0.01[c]	8.5 $\pm$ 0.02[c]	5.0 $\pm$ 0.06[c]
Spinach	1.9 $\pm$ 0.03[d]	10.2 $\pm$ 0.05[d]	6.0 $\pm$ 0.04[d]
Cauliflower	1.5 $\pm$ 0.05[e]	5.6 $\pm$ 0.03[e]	4.7 $\pm$ 0.03[e]
Amaranth	0.9 $\pm$ 0.05[f]	3.1 $\pm$ 0.04[f]	2.4 $\pm$ 0.05[f]
Carrot	0.8 $\pm$ 0.02[f]	1.8 $\pm$ 0.01[g]	3.2 $\pm$ 0.06[g]
CD ($p < 0.05$)	0.10	0.10	0.17

Values are mean $\pm$ SEM of three replicates. Figures within the column bearing different superscripts are significantly different.

expressed as percent of total iron was similar in carrots (7.7%), amaranth (7.6%) and coriander (7.5%). In vitro iron, as a percent of total iron, was also found to be similar in carrots, amaranth and coriander.

Ionizable iron, as a percent of total iron in spinach, was quite similar to the findings of other workers [5, 15] who reported 4.4 and 5.0 percent of total iron in spinach. Various factors affecting iron content of leaves are stage of maturity, conditions of growth, fertilizers used and nature of soil [23].

Copper content of green leafy vegetables ranged from 0.8 to 1.0 mg/100 g, manganese from 1.8 to 10.2 mg/100 g and zinc from 2.4 to 6.0 mg/100 g (Table 3). The values for manganese and zinc were significantly ($p < 0.05$) different in all the vegetables. Some workers reported 1.6 mg copper/100 g and 7.0 mg zinc/100 g in spinach [8] whereas others reported 8.7 mg manganese/100 g in spinach [14], which is quite similar to the findings of the present study. Almost an equivalent value for copper (0.8 mg/100 g) has been reported in amaranth leaves on dry weight basis [11].

Conclusion

Green leafy vegetables analyzed were found to be good source of ascorbic acid, β-carotene and iron. These green leafy vegetables should be included in the diet to overcome various nutritional problems like iron and vitamin A deficiency.

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