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Mineral Composition of Some Kabuli Chickpea (*Cicer arietinum* L.) Cultivars Leaves

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In this paper, the leaf mineral concentrations of ten nationally registered Kabuli type chickpea cultivars were characterized. Young, fully expanded leaves (fourth thorough seventh nodes from apex) were harvested at both early (30 d after emergence) and late (55 d after emergence) vegetative stages. The leaves were dried, ashed and analyzed for mineral concentrations. In general, N, P, K, Ca, Fe, Mn and Zn contents of chickpea plants were higher than those of common leafy vegetables such as spinach, radish, pepper, lettuce, cabbage, broccoli and celery. No major differences were observed in leaf mineral concentrations among the Kabuli type chickpea cultivars. Mineral concentrations were generally lower in leaves collected at the later harvest date except for P content of plants. Overall, chickpea leaves were found to be a good source of several minerals required for humans. Most of these leaf mineral contents significantly exceed those previously reported for common leafy vegetables.

Key Words: Macro, Micro mineral contents, Nutritional value, Chickpea.

INTRODUCTION

Chickpea is a legume which is widely consumed throughout the world. According to the size, shape and colour of seed, two biotypes are usually acknowledged. The Kabuli type chickpea, characterized by large seeds with a salmon-white testa, is mainly grown in the Mediterranean area, the Near East, Central Asia and America.The Desi type chickpea, characterized by small seeds with a coloured testa, is grown in India and East Africa[1]. It is generally accepted that the Kabuli type was derived from the Desi type through a mutation followed by conscious selection[2]. Moreover, a polymorphism has been reported between *Cicer arietinum* and its wild relative

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Cicer reticulatum[3]. Elsewhere, major environmental influences have often caused genotype-environmental interactions[4,5], yet the differences among cultivars are less pronounced than those due to cultivation in different agroclimatic regions[6]. Thus, genetic and biotype differences in chemical composition must be evaluated while excluding the agroclimatic effect. For instance, Dodd *et al.*[7] found great variations in mineral content due to the effect of the growing location. Differences have also been reported in the Cu and Zn contents for both biotypes due to the effects of their location[8,9].

In several developing countries, chickpea serves as a stable food for humans and can account for a significant proportion of daily caloric and nutrient intake[10]. Unfortunately, malnutrition and micronutrient deficiencies are prevalent in many chickpea-consuming regions[11], even though chickpea seeds are a good source of protein and can provide several essential minerals[12]. The nutritional problems stem from inadequate overall food intake, along with a low density of micronutrient minerals within the diet. New sources of nutrient-dense foods would be helpful, therefore, in the effort to alleviate these problems[13-16].

Although chickpea is predominantly consumed as a seed food, young leaves of the plant are also cooked and consumed as a vegetable green in India and Nepal[17,18]. Green vegetables rich in vitamins, minerals and various health-beneficial phytochemicals can play an important complementary role in an otherwise nutrient-incomplete diet[19]. For chickpea leaves, data on leaf mineral concentrations are limited[17-19], however, available reports on Fe, Zn and Cu suggest that this food could be a good source of these minerals. More information is needed on the concentrations of all nutrients essential to humans that are present in chickpea leaves and whether certain types and/or cultivars of chickpea might be more nutritious than others.

The aim of this study was to evaluate leaf mineral concentrations and differences in mineral composition of ten Kabuli type chickpea cultivars grown under the same environmental agronomic conditions in Turkey and to evaluate nutritional value of this food relative to other green vegetables.

EXPERIMENTAL

This study was carried out of the experimental farm of Atatürk University, Erzurum at Eastern Anatolia (29º 55'N and 41º 16'E at an altitude of 1850 m a.s.l), Turkey in 2005 using ten nationally registered Kabuli type chickpea cultivars (*Cicer arietinum* L. cvs. Aziziye-94, Akçin-91, Aydin-92, Küsmen-99, Gökçe, Diyar-95, Izmir-92, Damla-89, Canitez-87, Iliç 482). The annual precipitation was 384.0 mm in 2004-2005.

The experimental soil was a sandy loam with organic matter content between 1.68 and 1.87 % and lime content between 0.34 and 0.66 % (pH =

6.36-6.62). Available P_2O_5 content ranged between 87 and 119 kg ha^{-1} and K_2O content between 1422 and 1596 kg ha^{-1}. The experimental field received 40 kg N ha^{-1} in ammonium sulphate form and 60 kg P_2O_5 ha^{-1} in triple super phosphate form. The experimental design was randomized complete blocks with three replications. Each cultivar was planted by hand plots having 6 rows of 5 m length with 30 cm inter row spacing so as to give 40 seeds per m^2 on May 7, 2005.

Plant sampling and tissue analysis: Twenty young, fully expanded leaves (forth through seventh nodes from the apex of the main stem) were harvested for chemical analysis from each plot (*i.e.*, a total 60 leaves per plant cultivar) at early (30 d after emergence) and late vegetative stages (55 d after emergence, just prior to the initiation of flowering). The leaves were dried at 68 °C for 48 h.

Moisture content was determined gravimetrically by using fresh and dry weights of the plant material. Plant ash was determined by burning the material at 550 ºC. Ten fresh leaf materials were mixed with 50 mL deionized water and the volume was made up to 100 mL. After 12 h at 25 ºC, it was filtered and than extracting suspension was measured by pH meter. Total nitrogen was determined using the micro-Kjeldahl method[20]. Protein contents of plant species were determined[21] by multiplying N contents by a coefficient of 6.25.

Plants samples were washed to remove soil using deionized water. Plants samples were oven-dried at 68 ºC for 48 h and ground to pass 1 mm. The Kjeldahl method[20] and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Germany) were used to determine total N. Phosphorus and S contents were determined after wet digestion using a HNO_3-$HClO_4$ acid mixture (4:1 v/v). Phosphorus in the extraction solution was measured spectrophotometrically using the indophenol-blue and ascorbic acid method and a UV/Vis Aqumat Spectrophotometer (Thermo Electron Spectroscopy LTD, Cambridge, UK). K, Na, Ca and Mg, Fe, Mn, Zn and Cu were determined after wet digestion using a HNO_3-$HClO_4$ acid mixture (4:1 v/v). In the diluted digests, K, Na, Ca, Mg, Fe, Mn, Zn and Cu analysis were determined by atomic absorption spectrometry (Perkin Elmer 3690).

Statistical analysis: Statistical analyses were done using SAS statistical software[22].

RESULTS AND DISCUSSION

Mineral concentrations were determined in leaf samples (fourth through seventh nodes from the shoot apex) from ten Kabuli chickpea cultivars collected at early (30 d after emergence) and late vegetative stages (55 d after emergence).

Nitrogen and protein contents and pH of cultivars are given in Table-1. Nitrogen, protein and pH varied by plant cultivars and by harvest date. pH was the highest in the Damla-89 variety (6.14) and the lowest in Aziziye-94 (5.19) cultivars. Within each harvest date, few differences in mean pH degree were observed between chickpea cultivars. The chickpea cultivars harvested at early vegetative stage had higher pH values, as compared with the cultivars harvested at late vegetative stage.

Aziziye-94 had the highest ash (16.14 %) and moisture (5.13 %) content (Table-2) while Damla-89 had the lowest values (14.24 and 4.55 %, respectively). Ash contents of chickpea cultivars harvested at early vegetative stage were lower than cultivars harvested at late vegetative stage. This may be because moisture contents of chickpea cultivars harvested at early vegetative stage were higher than cultivars harvested at late vegetative stage.

Nitrogen and protein: Nitrogen and protein contents (Table-1) were the highest in Aziziye-94 and the lowest in Izmir-92. When compared with vegetative stage, chickpea cultivars harvested at late vegetative stage had higher N and protein contents.

Phosphorus: Phosphorus content among the various chickpea cultivars and harvest date was variable (Table-2). Phosphorus content was the highest in Aziziye-94 (150.46 mg 100 g^{-1}) and the lowest in Canitez-87 (132.29 mg 100 g^{-1}).

Potassium: Potassium content was the highest in Aziziye-94 (852 mg 100 g^{-1}) and the lowest in Iliç-482 (719 mg 100 g^{-1}).

Sulphur: Sulphur content among the various plant cultivars and harvest date was fairly variable. Sulphur content was the highest in Aziziye-94 (70.08 mg 100 g^{-1}) and the lowest in Iliç 482 (39.40 mg 100 g^{-1}).

Calcium: Calcium values of the cultivars ranged between 350 mg 100 g^{-1} (Aziziye-94) and 272 mg 100 g^{-1} (Izmir-92).

Magnesium: The highest and the lowest magnesium contents were found in Aziziye-94 (101.72 mg 100 g^{-1}) and Diyar-95 (79.11 mg 100 g^{-1}), respectively.

Sodium: Sodium content significantly changed among the chickpea cultivars. The lowest (0.89 mg 100 g^{-1}) and the highest (1.94 mg 100 g^{-1}) Na contents were determined in Izmir-92 and Aziziye-94, respectively.

Micro nutrients: Aziziye-94 had the highest Fe (3.09 mg 100 g^{-1}), Mn (1.22 mg 100 g^{-1}), Zn (2.44 mg 100 g^{-1}) and Cu (0.8 mg 100 g^{-1}) contents. The lowest Fe (1.46 mg 100 g^{-1}) and Cu (0.05 mg mg 100 g^{-1}) contents were determined in Diyar-95 and the lowest Mn (0.91 mg 100 g^{-1}) and Zn (1.07 mg 100 g^{-1}) contents were observed in Iliç 482 (Table-2).

TABLE-1
pH, PROTEIN AND NITROGEN CONTENTS OF KABULI CHICKPEA LEAVES (FOURTH THROUGH SEVENTH NODES FROM APEX) HARVESTED 30 AND 55 d AFTER EMERGENCE

Properties	Statistic	Aziziye	Akçin	Aydin	Küsmen	Gökçe	Diyar	Izmir	Damla	Canitez	Iliç
		30 d after emergence									
pH	Mean	5. 19	5.42	5.82	6.10	5.80	5.90	5.60	6.14	5.80	5.91
	SD	0.31	0.60	0.63	0.51	0.27	0.53	0.30	0.44	0.51	0.60
	CV	6.20	9.65	10.42	8.13	5.50	10.12	5.12	6.90	7.88	9.21
Protein (g 100 g^{-1})	Mean	11.74	10.00	10.69	8.63	8.06	8.25	7.63	8.69	8.57	8.12
	SD	0.51	1.03	0.46	0.33	0.51	0.38	0.43	0.71	0.54	0.71
	CV	9.47	22.42	12.97	10.67	9.55	6.40	10.17	9.79	21.79	30.38
N (g 100 g^{-1})	Mean	1.88	1.60	1.71	1.38	1.29	1.32	1.22	1.39	1.37	1.30
	SD	0.15	0.12	0.08	0.12	0.13	0.11	0.19	0.13	0.11	0.11
	CV	16.08	19.92	18.19	27.53	18.41	16.52	15.23	10.16	28.25	31.98
		55 d after emergence									
pH	Mean	5.05	5.03	5.39	5.78	5.24	5.33	5.10	5.89	5.10	5.06
	SD	0.35	0.43	0.40	0.39	0.51	0.24	0.43	0.42	0.51	0.55
	CV	8.41	6. 97	7.12	6.78	8.36	4.15	9.25	7.54	9.25	9.06
Protein (g 100 g^{-1})	Mean	13.63	12.19	12.56	10.75	11.31	9.69	9.00	10.13	10.06	9.38
	SD	0.57	0.50	0.41	0.44	0.62	0.53	0.72	0.50	0.51	0.58
	CV	13.82	5.00	5.89	11.30	17.57	16.43	27.77	9.06	21.42	15.55
N (g 100 g^{-1})	Mean	2.18	1.95	2.01	1.72	1.81	1.55	1.44	1.62	1.61	1.50
	SD	0.11	0.17	0.13	0.15	0.12	0.11	0.15	0.14	0.14	0.11
	CV	16.15	3.29	8.12	21.50	17.11	17.34	33.38	17.81	32.22	19.34

SD = Standard Deviation, CV = Coefficient of Variance.

TABLE-2
MINERAL CONTENTS OF KABULI CHICKPEA LEAVES (FOURTH THROUGH SEVENTH NODES FROM APEX) HARVESTED 30 AND 55 DAYS AFTER EMERGENCE

S.N.	Statistic	Moisture	Ash	P	K	S	Ca	Mg	Na	Fe	Mn	Zn	Cu
		(%)					mg 100 g^{-1} fresh weight for 30 d						
Aziziye	Mean	5.13	16.14	150.46	852	70.08	350	101.72	1.94	3.09	1.22	2.44	0.18
	SD	0.45	2.20	2.00	88.69	3.02	6.49	6.75	0.85	0.19	0.11	0.14	0.05
	CV	6.13	15.10	6.11	4.10	4.81	5.39	16.50	21.74	11.27	42.24	5.18	47.55
Akçin	Mean	4.94	15.94	133.11	786	66.92	324	98.03	1.21	2.81	1.04	1.95	0.14
	SD	0.66	1.81	1. 54	74.01	3.51	5.04	5.79	0.66	0.47	0.01	0.16	0.02
	CV	8.14	9.10	18.70	5.30	2.35	1.98	4.19	19.18	23.35	25.01	3.93	25.21
Aydin	Mean	5.10	15.96	140.27	772	49.84	327	90.33	1.29	2.77	1.08	2.10	0.11
	SD	0.56	1.71	3.09	68.01	3.71	7.14	5.64	0.57	0.29	0.09	0.15	0.04
	CV	7.10	9.05	18.19	29.51	6.03	26.74	12.61	5.13	10.56	11.12	8.97	37.47
Küsmen	Mean	5.00	15.24	141.49	753	48.85	303	97.34	1.59	2.52	1.12	2.12	0.10
	SD	0.42	2.32	3.11	91.83	2.88	5.18	5.20	0.95	0.28	0.10	0.16	0.09
	CV	13.88	10.61	17.15	2.53	7.13	1.31	11.37	8.41	16.89	13.27	8.32	19.86
Gökçe	Mean	5.11	15.88	140.74	761	58.57	295	83.80	1.03	1.99	1.08	1.97	0.11
	SD	0.68	2.30	3.20	85.42	4.30	4.32	4.25	0.94	0.32	0.07	0.15	0.06
	CV	12.18	10.13	5.18	3.32	4.52	6.69	2.13	5.04	20.55	8.23	6.11	35.25
Diyar	Mean	5.05	15.84	141.48	765	48.23	281	79.11	1.19	1.46	1.16	1.88	0.05
	SD	0.51	2.50	3.11	85.63	3.09	3.83	6.00	0.39	0.36	0.08	0.13	0.03
	CV	13. 64	11.21	30.27	2.30	6.48	1.36	13.81	13.24	13.18	11.81	3.62	32.95
Izmir	Mean	4.98	16.09	139.34	749	50.53	272	86.94	0.89	2.19	1.04	1.86	0.10
	SD	0.74	3.17	3.91	68.43	3.52	5.54	5.82	0.70	0.42	0.08	0.14	0.03
	CV	11.70	12.00	22.31	3.15	3.50	1.41	10.20	1.23	9.21	7.28	5.29	31.49

S.N.	Statistic	Moisture	Ash	P	K	S	Ca	Mg	Na	Fe	Mn	Zn	Cu
		(%)		mg 100 g^{-1} fresh weight for 30 d									
Damla	Mean	4.55	14.24	137.93	798	43.51	312	79.34	1.06	2.72	1.13	2.29	0.11
	SD	0.85	2.15	3.13	74.17	3.00	2.31	6.52	0.57	0.48	0.08	0.09	0.005
	CV	13.02	8.59	8.05	4.41	3.59	1.84	13.28	4.65	15.82	12.91	2.52	39.96
Canitez	Mean	4.90	14.54	132.29	788	44.61	273	80.67	1.12	2.39	0.93	1.75	0.08
	SD	0.78	2.20	3.69	93.30	2.77	4.47	5.29	0.72	0.45	0.06	0.14	0.06
	CV	14.17	13.54	28.16	33.10	6.19	2.17	13.13	8.25	15.75	15.34	5.19	67.25
Iliç	Mean	4.80	14.83	142.04	719	39.40	353	93.08	1.06	2.90	0.91	1.07	0.09
	SD	0.69	1.30	4.11	73.50	2,11	3.81	6.19	0.66	0.28	0.09	0.17	0.006
	CV	14.63	10.50	40.16	5.80	5.34	1.42	2.37	1.29	9.13	10.12	3.67	28.21
				mg 100 g^{-1} fresh weight for 55 d									
Aziziye	Mean	4.67	18.70	160.77	772	62.73	421.00	44.83	1.49	1.91	0.33	0.68	0.072
	SD	0.65	2.85	3.25	85.32	3.11	2.73	4.75	0.62	0.16	0.04	0.05	0.003
	CV	17.59	15.22	140.41	11.05	4.95	0.64	10.60	11.26	8.40	13.75	12.08	4.40
Akçin	Mean	3.65	18.32	120.55	680	59.56	371.00	40.36	1.40	1.82	0.37	0.40	0.063
	SD	0.64	2.38	3.85	109.51	3.13	4.28	4.69	0.40	0.13	0.07	0.05	0.025
	CV	13.79	12.99	30.72	7.93	2.61	1.59	11.64	3.04	15.59	19.77	27.13	48.93
Aydin	Mean	4.87	17.36	160.94	677	47.49	389.00	36.72	1.59	1.22	0.39	0.48	0.012
	SD	0.74	1.37	5.27	149.60	3.03	8.08	4.42	0.64	0.18	0.14	0.04	0.004
	CV	15.25	7.87	31.11	7.97	6.38	4.28	12.03	24.95	14.57	35.03	14.65	36.71
Küsmen	Mean	4.79	16.53	140.25	699	39.29	352.00	32.67	1.67	1.56	0.32	0.43	0.099
	SD	0.65	1.88	3.32	79.87	3.11	5.96	4.73	0.39	0.17	0.12	0.05	0.03
	CV	9.51	8.34	7.52	15.98	3.49	11.53	14.49	23.32	30.09	38.70	14.08	29.83

S.N.	Statistic	Moisture	Ash	P	K	S	Ca	Mg	Na	Fe	Mn	Zn	Cu
		(%)		mg 100 g^{-1} fresh weight for 30 d									
Gökçe	Mean	4.81	16.84	159.06	615	45.22	328.00	35.17	1.22	1.59	0.23	0.76	0.011
	SD	0.69	3.11	4.20	57.39	3.46	4.11	8.49	0.70	0.08	0.07	0.06	0.004
	CV	14.39	19.65	10.77	3.16	2.76	5.28	24.16	9.72	5.35	57.02	8.10	39.52
Diyar	Mean	4.18	16.08	151.08	610	40.53	296.49	38.17	1.04	1.20	0.24	0.41	1.17
	SD	1.13	1.51	4.13	118.00	3.38	7.70	3.50	0.45	0.19	0.10	0.04	0.038
	CV	21.82	9.4	10.05	19.34	4.79	10.07	9.17	22.39	91.92	42.47	12.27	3.27
Izmir	Mean	4.11	17.52	165.36	673.23	44.12	329.00	30.37	1.32	1.11	0.13	0.59	0.011
	SD	0.80	3.00	2.99	121.62	3.23	4.54	4.95	0.52	0.18	0.07	0.05	0.006
	CV	19.55	22.23	55.77	32.59	13.41	15.22	16.30	0.88	15.99	53.35	16.58	65.97
Damla	Mean	3.58	15.12	150.53	690	39.92	397.00	42.11	1.76	1.36	0.17	0.58	0.032
	SD	0.49	2.89	4.28	74.76	1.75	6.20	5.85	0.72	0.18	0.13	0.06	0.005
	CV	13.73	16.93	40.61	5.02	2.20	1.42	13.89	4.06	13.46	77.53	30.51	15.88
Canitez	Mean	4.52	16.93	142.33	624	35.70	282.84	36.47	1.45	1.25	0.14	0.49	0.14
	SD	0.97	3.03	3.19	87.63	2.59	4.09	6.42	0.63	0.13	0.01	0.068	0.06
	CV	27.49	18.19	14.31	14.03	3.42	4.93	17.60	43.51	49.82	39.77	36.37	44.54
Iliç	Mean	4.03	15.07	155.57	623	34.05	416.00	35.65	1.70	1.74	0.081	0.39	0.011
	SD	0.89	2.12	3.29	64.32	3.87	7.38	6.40	0.57	0.19	0.001	0.04	0.004
	CV	22.18	19.15	59.01	10.32	8.79	2.49	17.97	1.07	24.94	1.12	12.58	39.98

SD = Standard Deviation, CV = Coefficient of Variance.

Most of the cultivars analyzed in the present study were found to contain significant quantities of variety of essential nutrients. The highest macro and micro element contents were observed in Aziziye-94 cultivar. Across the two harvest dates and within each chickpea cultivars, mineral concentrations were generally lower in leaves collected at the late vegetative stage. Exceptions to this tendency were seen for Ca and P. It should be stressed that leaves at each harvest were collected from the forth through seventh nodes (from the shoot apex) and thus a different population of leaves was collected at day 55 relative to day 30. Plants were much bigger at day 55 and it is possible that the partioning of root-absorbed nutrients through the larger shoot mass of older plants may have let to a lower overall delivery of nutrients to the terminal leaves.

Ten Kabuli chickpea cultivars were grown under the same environmental conditions in order to characterize the mineral nutritional value leaves as food source for humans. Although variation was observed in mineral concentrations among the harvest date, no major differences were seen between the plant cultivars. The concentrations observed for all minerals in this study were within the acceptable ranges reported for mature leaves from other species[23,24]. Because the focus of this study was on chickpea leaves as a food sources, we were interested in assessing their nutritional value relative to other leafy vegetables. Data obtained from chickpea plants show that they had a very high nutritional potential and their mineral content was greater than that of some leafy vegetables presented in Table-3. The chickpea plants may offer a good nutritional potential. Compared with some leafy vegetables, in general chickpea plant mineral content was higher than those of some culture plants such as spinach, radish, pepper, lettuce, cabbage, broccoli and celery (Table-3).

TABLE-3
MINERAL CONTENTS OF SOME SELECTED CULTIVATED VEGETABLES[28]

Species	Protein (g 100/g)	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
		mg 100/g fresh weight								
Spinach	2.2	0.35	49	558	160	79	2.6	0.10	0.5	0.9
Radish	3.5	0.57	44	370	100	26	3.8	0.11	0.5	0.5
Pepper	5.5	0.46	80	220	30	24	1.2	0.14	0.4	0.5
Lettuce	0.8	0.13	28	220	28	6	0.7	0.01	0.2	0.3
Cabbage	1.0	0.16	25	246	47	14	0.6	0.01	0.3	0.2
Broccoli	3.1	0.50	57	170	40	13	1.0	0.12	0.4	0.2
Celery	0.9	0.15	63	330	40	63	0.7	0.11	0.3	0.1
Asparagus	1.6	0.26	50	220	25	13	0.6	0.08	0.1	0.2

For instance, calcium, which is important for bone growth and muscle strengthen, was most abundant in Aziziye-94 cultivars leaves. Considering that the daily requirement of calcium is 1200 mg, one modest serving chickpea leaves (*ca.* 10 g) per day would more than satisfy a daily calcium requirement[25].

Iron is required for hemoglobin formation. Anaemia, due to hookworms and iron deficiency, is a widespread problem. Similarly, zinc, a trace mineral that is especially important for the normal functioning of the immune system, was relatively abundant in Kabuli chickpea cultivars leaves.

Many people living in Anatolia rely almost exclusively on farming and gathering and therefore are generally vegetarians. As in many vegetarian diets, protein quality and quantity are major concerns. Most plants contain incomplete proteins, but eating a combination different plant food (nutrient supplementation) can insure a supply of complete proteins. Lack of adequate protein, either in quality or quantity contributes to low body mass, growth retardation in children and infancy which developmental problems during pregnancy. The average adult requires *ca.* 0.8 g of protein per kg of lean body mass per day to maintain normal function; so, a 70 kg person needs *ca.* 56 g of protein a day.

Conclusion

The present study reveals that young leaves of several tested cultivars of Kabuli chickpea can contain high levels of N, P, K, Ca, Fe, Mn and Zn, comparing favourably with other common leafy vegetables. Thus, chickpea leaves show great promise as a dietary source of several human essential minerals, especially for populations where malnutrition and micronutrient deficiencies are prevalent[26,27]. In general, N, P, K, Ca, Fe, Mn and Zn contents of chickpea plants were higher than spinach, radish, pepper, lettuce, cabbage, broccoli and celery vegetables. It is very important that chickpea plants are the least expensive sources for a number of nutrients and provide macro and micro minerals.

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