

Mineral Contents of Chickpea Cultivars (*Cicer arietinum* L.) Grown at Different Locations of Turkey

(Kandungan Mineral Tanaman Kultivar Kacang Kuda (*Cicer arietinum* L.) di Lokasi Berbeza di Turki)

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ABSTRACT

Mineral deficiency-induced diseases and health problems influence billions of people worldwide. Development of edible legumes with high mineral contents will provide significant contributions in reducing the frequency of such diseases. Among the edible legumes, chickpea has quite high nutritional values and quite low production costs, thus commonly grown and consumed worldwide. This study was conducted to determine mineral (potassium, phosphorus, sulphur, calcium, magnesium, sodium, zinc, iron, boron, manganese, copper) contents of eight different chickpea cultivars (Akçin-91, Azkan, Hisar, Akça, Gökçe, Yaşa-05, Işık-05 and Çakır) grown in two different locations (Afyonkarahisar and Yozgat provinces of Turkey) for two years (2015 and 2016). Experiments were conducted in randomized blocks design with three replications. Among the minerals, potassium was highest (6435.2-8231.7 mg kg⁻¹) followed by phosphorus (2573.9-3094.0 mg kg⁻¹) and sulphur (1710.9-2060.7 mg kg⁻¹). Among the minerals, copper was lowest followed by boron and manganese. Considering the average of locations, it was observed that Gökçe, Akçin-91, Azkan and Hisar cultivars were prominent with sulphur content; Akça with boron, sodium and calcium contents; Yaşa-05 and Işık-05 with potassium, phosphorus, magnesium, zinc, iron, magnesium, manganese and copper contents. Çakır cultivar was stable for all minerals. The concentrations of seed P, S, Ca, Mg, B and Mn were significantly affected by locations.

Keywords: Cultivar; mineral; potassium; quality

ABSTRAK

Penyakit disebabkan kurang mineral dan masalah kesihatan mempengaruhi berbilion orang di seluruh dunia. Pembangunan kekacang yang boleh dimakan dengan kandungan mineral yang tinggi akan memberi sumbangan yang besar dalam mengurangkan kekerapan penyakit tersebut. Antara kekacang yang boleh dimakan, kacang kuda mempunyai nilai nutrisi yang agak tinggi dengan kos pengeluaran yang agak rendah dan umumnya ditanam dan dimakan di seluruh dunia. Kajian ini dijalankan untuk mengenal pasti kandungan mineral (kalium, fosforus, sulfat, kalsium, magnesium, natrium, zink, besi, boron, mangan, kuprum) lapan jenis kacang kuda berbeza kultivar (Akçin-91, Azkan, Hisar, Akça, Gökçe, Yaşa-05, Işık-05 dan Çakır) ditanam di dua lokasi berbeza (Wilayah Afyonkarahisar dan Yozgat, Turki) selama dua tahun (2015 dan 2016). Uji kaji telah dijalankan dalam reka bentuk blok rawak dengan tiga replikasi. Antara mineral, kalium adalah tertinggi (6435.2-8231.7 mg kg⁻¹) diikuti dengan fosforus (2573.9-3094.0 mg kg⁻¹) dan sulfat (1710.9-2060.7 mg kg⁻¹). Antara mineral, kuprum adalah paling rendah diikuti dengan boron dan mangan. Mengambil kira purata lokasi, telah diperhatikan bahawa kultivar Gökçe, Akçin-91, Azkan dan Hisar menonjol dengan kandungan sulfat; Akça dengan boron, natrium dan kandungan kalsium; Yaşa-05 dan Işık-05 dengan kalium, fosforus, magnesium, zink, besi, mangan dan kandungan kuprum. Kultivar Çakır adalah stabil untuk semua mineral. Kepekatan benih P, S, Ca, Mg, B dan Mn dengan ketara terjejas disebabkan lokasi.

Kata kunci: Kalium; kualiti; kultivar; mineral

INTRODUCTION

Mineral deficiency-induced diseases and health problems influence billions of people worldwide. Mineral deficiencies are commonly treated with diet supplements or supplemented foodstuffs. They are quite rich in carbohydrates, proteins, vitamins and minerals (Wang et al. 2010). Legumes have an irreplaceable place in vegetarian diets of developing countries; they have low glycemic index for patients with diabetes (Viswanathan & Sudha 1989) and they have several positive health impacts including prevention of cancer (Hangen & Bennink 2002) and cardiovascular diseases (Lee et al. 1992). Development

of legume species with high mineral contents will contribute to reduce frequency of such diseases.

With regard to nutritional attributes, chickpea is among the most significant plants. With about 14 million tons of annual production, it has the third place in edible legumes worldwide. On the other hand, in Turkey, with 630 thousand tons of annual production, chickpea has the first place in edible legumes of the country (FAO 2017; TÜİK 2017). Chickpea is quite rich in minerals; 100 g of it contains 875 mg potassium, 331 mg phosphorus, 105 mg calcium, 24 mg sulphur, 11.5 mg magnesium, 8.2 mg selenium, 6.2 mg iron and 3.4 mg zinc (Khetarpaul 2018).

With these values, entire Fe and Zn needs and half of Mg needs of daily diets are met (Jukanti et al. 2012). Chickpea is also a good source of carbohydrates (38.01-59.0%) and proteins (14.9-24.6%) (Yalçın et al. 2018). Chickpea with a well-balanced amino acid, high protein digestibility and low anti-nutritional attributes, thus accepted as a suitable source of diet for (Wood & Grusak 2007). Just because of increasing world population, limited production sources, imbalanced resource allocations and high-costs of animal-originated proteins, almost half of world population is undernourished. Chickpea with high nutritive values and low cost of production, thus has commonly consumed worldwide.

Cultivar selection in chickpea is generally performed based on agronomic traits. Effects of genetics, environment and their interactions on mineral composition should be determined while selecting chickpea cultivars with high mineral contents. In this study, field experiments were conducted with eight common chickpea cultivars of Turkey at two different locations (Afyonkarahisar and Yozgat provinces) for two years (2015 and 2016) and mineral composition of these chickpea cultivars were determined.

MATERIALS AND METHODS

SEED MATERIALS

In this study, eight commonly grown chickpea cultivars of Turkey (Akçin-91, Azkan, Hisar, Akça, Gökçe, Yaşa-05, Işık-05 and Çakır) were used as the plant material.

FIELD EXPERIMENT

Experiments were conducted at two different locations (experimental fields of Bozok University at Yerköy town of Yozgat province and farmer fields at Çay town of Afyonkarahisar province) for two years (2015 and 2016). Altitude is 1.021 m in Afyonkarahisar location and 771 m in Yozgat location. In both locations, sowings were performed in April. Harvest was performed on 16 August of the first year and 28 July of the second year in Afyonkarahisar location; on 5 August of the first year and 15 August of the second year in Yozgat location.

Climate data for experimental years are provided in Table 1. Throughout the vegetation period, total precipitation was 167.4 mm, average temperature was 18.9°C and average relative humidity was 65.0% in Afyonkarahisar; the values, respectively, were 193.0 mm, 16.62°C and 53.7% in Yozgat.

Soil characteristics of the experimental locations were identical in both years. Soil samples were taken from 0-30 cm soil profile and analysis results are provided in Table 2.

SAMPLES PREPARATION AND ANALYTICAL METHODS

Harvested chickpea seeds stored at 4°C until analysis. The seeds were oven dried at 55°C and ground in a cyclone sample. Ground samples were then weighed into tared porcelain crucibles (2 g in each). Ash oven was gradually brought to 550°C and Ash was determined by incineration of known weights of the chickpea flour samples in a muffle furnace at 550°C for 8 h. Samples were cooled in

TABLE 1. Meteorological data for the experiment areas

Location	Years/Months	April	May	June	July	August	Total/Average	
Afyonkarahisar	Rainfall (mm)	2015	51.8	91.4	133.0	11.2	82.8	370.2
		2016	22.8	97.2	6.6	12.8	91.2	230.6
		Long-term	46.8	51.8	37.1	19.5	12.2	167.4
	Temperature (°C)	2015	7.6	15.3	16.4	21.4	21.2	16.4
		2016	13.0	14.0	20.2	22.2	21.9	18.3
		Long-term	11.3	16.3	20.1	23.6	23.4	18.9
	Humidity (%)	2015	70.0	67.0	81.0	58.0	67.0	68.6
		2016	58.0	70.0	56.0	51.0	62.0	59.4
		Long-term	65.0	69.0	68.5	56.2	66.3	65.0
	Rainfall (mm)	2015	28.0	131.6	95.3	7.1	5.4	267.4
		2016	24.6	101.5	29.1	0.8	0.4	156.4
		Long-term	62.0	65.3	44.4	12.4	8.9	193.0
Yozgat	Temperature (°C)	2015	6.1	14.1	16.0	19.8	21.5	15.5
		2016	11.8	12.6	18.5	20.7	23.5	17.4
		Long-term	10.0	14.1	17.6	20.6	20.8	16.6
	Humidity (%)	2015	61.9	59.9	71.5	54.7	54.0	60.4
		2016	49.1	66.8	57.8	50.3	49.3	54.7
		Long-term	55.2	59.3	56.6	48.6	48.6	53.7

TABLE 2. Soil characteristics in the experimental areas*

Characteristics	Afyonkarahisar		Yozgat	
Potassium (kg ha ⁻¹)	222.3	high	49.3	high
Phosphorus (kg ha ⁻¹)	8.46	medium	8.30	medium
Lime (%)	4.4	lime	7.4	medium lime
Organic matter (%)	1.63	low	1.7	low
Salinity (%)	0.021	saltless	0.014	saltless
pH	7.7	slightly alkaline	8.4	slightly alkaline
Saturation (%)	57.0	clay-loam	55.9	clay-loam

* Yozgat agriculture chamber laboratory

desiccators and supplemented with 4 mL 3 N HCl. Samples were placed over hot-plate for about 10-15 min and they were filtered through filter papers into 100 mL polyethylene tubes with the aid of distilled water. Tubes were then completed to 100 mL with ultra-distilled water (Kaçar 1984). Resultant solutions were subjected to potassium (K), phosphorus (P), sulphur (S), calcium (Ca), magnesium (Mg), sodium (Na), zinc (Zn), iron (Fe), boron (B), manganese (Mn) and copper (Cu) analyses with the aid of Inductive Coupled Plasma - Mass Spectrophotometer (ICP-MS) device at Laboratories of Scientific and Technology Implementation and Research Center of Bozok University.

STATISTICAL ANALYSIS

Experiments were conducted in randomized complete blocks design with three replications (Gomez & Gomez 1984). Separate and combined statistical analyses of the locations were performed with SAS software (SAS 1998).

Means were compared with Tukey's test. Simple correlations were computed between different minerals using the SPSS 16.0 packet program. Biplot graph was generated with the use of MultBiplotsoftware.

RESULTS AND DISCUSSION

Experiments were conducted with eight different chickpea cultivars at two different locations (Afyonkarahisar and Yozgat) for two years (2015 and 2016). Variance analysis results for investigated traits are provided in Table 3; mean values of investigated traits are provided in Tables 4 and 5; correlations between the investigated traits are provided in Table 6 and resultant biplot graph is presented in Figure 1.

POTASSIUM (K) CONTENT

With regard to potassium contents, differences between the cultivars were found to be significant in Afyonkarahisar

TABLE 3. Variance analyses of the investigated mineral matters

General	K	P	S	Ca	Mg	Na	Zn	Fe	B	Mn	Cu
Afyonkarahisar											
Year (Y)	ns	ns	ns	**	*	ns	**	**	**	**	**
Cultivar (C)	**	*	ns	**	**	**	ns	**	**	**	**
Y × C	*	**	ns	ns	*	**	**	*	*	ns	**
Yozgat											
Year (Y)	ns	*	**	**	**	ns	**	ns	ns	**	ns
Cultivar (C)	**	*	*	*	**	ns	**	**	ns	**	**
Y × C	**	**	**	ns	**	*	**	*	*	ns	**
Mean											
Year (Y)	ns	ns	ns	*	ns	ns	**	ns	*	**	ns
Location (L)	**	ns	*	**	**	ns	ns	ns	**	**	ns
Y × L	ns	*	*	**	**	ns	*	**	ns	**	**
Cultivar(C)	**	**	*	**	**	**	**	**	**	**	**
Y × C	**	**	*	ns	**	**	**	**	**	ns	**
L × C	ns	*	*	ns	**	*	ns	**	ns	**	**
Y × L × C	*	**	*	ns	**	**	**	ns	ns	ns	**

K: potassium, P: phosphorus, S: sulfur, Ca: calcium, Mg: magnesium, Na: sodium, Zn: zinc, Fe: Iron, B: boron, Mn: manganese, Cu: copper, ns: not significant, *Significant at P<0.05, **Significant at P<0.01

TABLE 4. Average of mineral matter contents of chickpea varieties grown in different locations (mg kg⁻¹)

	K content						P content					
	Afyonkarahisar		Yozgat		Mean		Afyonkarahisar		Yozgat		Mean	
Çakır	7190.0	cd	7344.6	abc	7267.3	cd	2573.9	c	2932.2	abc	2573.9	c
Akça	7974.7	abc	7308.0	abc	7641.3	bc	2679.3	cb	2652.2	bc	2679.3	cb
Azkan	7644.4	abcd	6342.9	de	6993.6	de	2964.5	ab	2549.7	c	2964.5	ab
Akçin-91	7444.8	bcd	6991.1	cd	7217.9	cd	2577.9	c	2752.2	abc	2577.9	c
Hisar	6818.6	d	6051.8	e	6435.2	e	2628.6	c	2514.1	c	2628.6	c
Yaşa-05	8467.0	a	7943.2	ab	8205.1	ab	3094.0	a	3121.6	a	3094.0	a
Gökçe	7929.6	abc	7066.6	bcd	7498.1	cd	2815.2	abc	2571.5	c	2815.2	abc
Işık-05	8360.7	abc	8102.8	a	8231.7	a	2836.6	abc	3061.4	ab	2836.6	abc
<i>Mean</i>	<i>7728.7</i>	<i>b</i>	<i>7143.9</i>	<i>a</i>	<i>7436.3</i>		<i>2771.3</i>		<i>2769.4</i>		<i>2771.3</i>	
	S content						Ca content					
	Afyonkarahisar		Yozgat		Mean		Afyonkarahisar		Yozgat		Mean	
Çakır	1710.9		1807.2	ab	1759.1	ab	972.5	cd	1306.8	abc	1139.6	bc
Akça	1786.2		1710.9	ab	1748.6	ab	1259.3	a	1370.2	a	1314.8	a
Azkan	1868.0		1935.1	a	1901.5	a	1026.0	bed	1102.2	bc	1064.1	cd
Akçin-91	1868.8		1763.4	ab	1816.1	ab	1018.5	bed	1079.0	c	1048.7	cd
Hisar	1821.0		1942.4	a	1881.7	ab	936.2	d	1089.8	bc	1013.0	d
Yaşa-05	1938.4		1614.3	b	1776.3	ab	1076.4	bc	1133.7	bc	1105.0	cd
Gökçe	2063.7		1743.8	ab	1903.7	a	1021.7	bed	1117.2	bc	1069.4	cd
Işık-05	1805.5		1635.9	b	1720.7	b	1125.9	b	1322.5	ab	1224.2	ab
<i>Mean</i>	<i>1857.8</i>	<i>a</i>	<i>1769.1</i>	<i>b</i>	<i>1813.5</i>		<i>1054.6</i>	<i>b</i>	<i>1190.2</i>	<i>a</i>	<i>1122.4</i>	
	Mg content						Na content					
	Afyonkarahisar		Yozgat		Mean		Afyonkarahisar		Yozgat		Mean	
Çakır	1046.6	c	1141.2	a	1093.9	bc	496.5	c	565.5		531.0	bcd
Akça	1287.4	a	1042.3	ab	1164.9	ab	786.5	a	641.6		714.0	a
Azkan	1166.5	b	890.8	b	1028.6	cde	648.2	b	441.3		544.7	bcd
Akçin-91	1027.0	c	968.5	b	996.2	de	430.2	c	490.8		460.5	d
Hisar	1024.5	c	906.7	b	967.1	e	514.5	c	520.0		517.2	bcd
Yaşa-05	1226.4	ab	1151.6	a	1189.0	a	505.2	c	693.1		599.2	abc
Gökçe	1120.0	bc	993.0	b	1056.5	cd	482.6	c	480.6		481.6	cd
Işık-05	1172.6	ab	1144.8	a	1158.7	ab	551.6	bc	709.8		630.7	ab
<i>Mean</i>	<i>1133.9</i>	<i>a</i>	<i>1029.9</i>	<i>b</i>	<i>1081.9</i>		<i>551.9</i>		<i>567.8</i>		<i>559.9</i>	
	Zn content						Fe content					
	Afyonkarahisar		Yozgat		Mean		Afyonkarahisar		Yozgat		Mean	
Çakır	19.68		22.14	b	20.91	b	42.10	bc	45.30	bc	43.70	bc
Akça	18.79		18.88	b	18.84	b	44.50	abc	40.80	bcd	42.60	cd
Azkan	20.03		19.32	b	19.68	b	44.40	abc	37.80	d	41.10	cd
Akçin-91	19.15		21.30	b	20.23	b	42.80	abc	41.30	bcd	42.10	cd
Hisar	18.84		19.49	b	19.17	b	41.60	c	39.00	cd	40.30	d
Yaşa-05	21.15		20.74	b	20.94	b	45.60	ab	47.00	b	46.30	b
Gökçe	20.93		19.32	b	20.12	b	44.00	abc	40.90	bcd	42.40	cd
Işık-05	21.02		25.93	a	23.48	a	46.20	a	53.60	a	49.90	a
<i>Mean</i>	<i>19.91</i>		<i>20.85</i>		<i>20.26</i>		<i>43.90</i>		<i>43.21</i>		<i>46.55</i>	

	B content						Mn content					
	Afyonkarahisar		Yozgat		Mean		Afyonkarahisar		Yozgat		Mean	
Çakır	14.08	bc	13.43		13.76	bc	16.80	c	16.90	ab	16.85	b
Akça	15.27	a	14.33		14.80	a	19.52	ab	14.48	bcd	17.00	b
Azkan	14.42	ab	12.65		13.53	c	19.60	ab	14.27	cd	16.93	b
Akçin-91	14.05	bc	13.38		13.72	bc	18.28	bc	14.82	a-d	16.55	b
Hisar	13.47	c	12.88		13.18	c	16.92	c	12.83	d	14.88	c
Yaşa-05	14.02	bc	13.78		13.90	bc	20.95	a	16.68	a	18.82	a
Gökçe	14.43	ab	12.72		13.58	c	18.33	bc	14.42	bcd	16.38	b
Işık-05	14.63	ab	14.33		14.48	ab	18.43	bc	15.87	abc	17.15	b
<i>Mean</i>	<i>14.25</i>	<i>a</i>	<i>13.39</i>	<i>b</i>	<i>13.83</i>		<i>18.67</i>	<i>a</i>	<i>15.04</i>	<i>b</i>	<i>16.82</i>	

	Cu content					
	Afyonkarahisar		Yozgat		Mean	
Çakır	1710.9		1807.2	ab	1759.1	ab
Akça	1786.2		1710.9	ab	1748.6	ab
Azkan	1868.0		1935.1	a	1901.5	a
Akçin-91	1868.8		1763.4	ab	1816.1	ab
Hisar	1821.0		1942.4	a	1881.7	ab
Yaşa-05	1938.4		1614.3	b	1776.3	ab
Gökçe	2063.7		1743.8	ab	1903.7	a
Işık-05	1805.5		1635.9	b	1720.7	b
<i>Mean</i>	<i>7.359</i>		<i>6.948</i>		<i>7.149</i>	

and Yozgat locations. Since the year-based responses of the cultivars were different in both locations, year \times cultivar interactions were also found to be significant (Table 3). In Afyonkarahisar, K contents varied between 6818.6 (Hisar) and 8467.0 (Yaşa-05) mg kg⁻¹ and the cultivars Akça, Azkan, Gökçe and Işık-05 were placed in the same statistical group with Yaşa-05 with the greatest K content. In Yozgat, K contents of the cultivars varied between 6051.8 (Hisar) and 8102.8 (Işık-05) mg kg⁻¹ and the cultivars Çakır, Akça and Yaşa-05 were placed in the same statistical group with Işık-05 with the greatest K content (Table 4).

Combined analyses on K contents showed significant differences between the locations and between the cultivars. Year \times cultivar and year \times location \times cultivar interactions were found to be significant (Table 3). K contents of the cultivars varied between 6435.2 (Hisar) and 8231.7 (Işık-05) mg kg⁻¹ with an average value of 7436.3 mg kg⁻¹. K contents were lower in Afyonkarahisar than in Yozgat. Such a case indicated different responses of cultivars to different years and ecologies (Table 3). Potassium increases protein ratio of the plants and improves quality through uniform and early ripening of the kernels. Potassium also prevents shrinking of legume seeds (Kacar & Katkat 1988). Average K content was greater in Afyonkarahisar (7728.7 mg kg⁻¹) than in Yozgat (7143.9 mg kg⁻¹) (Table 4). In previous studies, chickpea K contents were reported as between 239.0 - 263.0 mg 100g⁻¹ (Haq et al. 2007), between 7480 - 7487 ppm (Ceran

2015), between 8711.5 - 9014.6 mg kg⁻¹ (Kahraman et al. 2015) and between 4698 - 7423 mg kg⁻¹ (Bayrak & Onder 2017).

PHOSPHORUS (P) CONTENT

With regard to P content, cultivars were found to be significant in Afyonkarahisar; years and cultivars were found to be significant in Yozgat. Year \times cultivar interactions were found to be significant in both locations (Table 3). In Afyonkarahisar, P contents varied between 2573.9 (Çakır) and 3121.6 (Yaşa-05) mg kg⁻¹ and the cultivars Azkan, Gökçe and Işık-05 were placed in the same statistical group with Yaşa-05 with the greatest P content. In Yozgat, P contents varied between 2514.1 (Hisar) and 3121.6 (Yaşa-05) mg kg⁻¹ and the cultivars Çakır, Akçin-91 and Işık-05 were placed in the same statistical group with Yaşa-05 with the greatest P content (Table 4). While the differences in P content of the years were not significant in Afyonkarahisar, average P content was 2869.5 mg kg⁻¹ in 2015 and 2669.1 mg kg⁻¹ in 2016 in Yozgat (Table 5). Such a case was attributed to greater precipitations in June 2015 in both locations.

Combined analyses on P contents showed significant differences between the cultivars. Year \times location, year \times cultivar, location \times cultivar and year \times location \times cultivar interactions were found to be significant (Table 3). According to combined variance analysis, P contents of the cultivars varied between 2514.1 (Hisar) and 3107.8

(Yaşa-05) mg kg⁻¹ with an average value of 2771.3 mg kg⁻¹ (Table 4). Significant year × cultivar and location × cultivar interactions were resulted from different responses of cultivars to years and locations. In previous studies, P contents of chickpea were reported as between 377.0 - 396.0 mg 100 g⁻¹ (Mut & Gulumser 1998), between 1109 - 1272 mg 100 g⁻¹ (Haq et al. 2007), between 3853.81 - 3572.91 ppm (Ceran 2015), between 2912.4 - 3379.9 mg kg⁻¹ (Kahraman et al. 2015), between 2257.01 - 3590.37 mg kg⁻¹ (Bayrak & Onder 2017) and between 3516 - 4246 ppm (Vandemark et al. 2018). Some other researchers reported average P contents as 226 mg 100 g⁻¹ (Alajaji & El-Adawy 2006), as 251 mg 100 g⁻¹ (Iqbal et al. 2006), as 423 mg 100 g⁻¹ (Wang et al. 2010) and as 2810 mg kg⁻¹ (Haq et al. 2007). Phosphorus plays a great role in cell division, fruit and seed formation. Soil phosphorus levels, phosphorous fertilizers and bacteria inoculations may improve kernel phosphorus contents. Ceran (2015), reported that late-sowings increased kernel phosphorus contents.

SULPHUR (S) CONTENT

While there were not significant differences in S contents in Afyonkarahisar, years, cultivars and year × cultivar interactions were found to be significant in Yozgat (Table 3). In Afyonkarahisar, S contents varied between 1710.9 (Çakır) and 2063.7 (Gökçe) mg kg⁻¹. In Yozgat, S contents varied between 1614.3 (Yaşa-05) and 1942.4 (Hisar) mg kg⁻¹ and all cultivars, except for Yaşa-05 and Işık-05, were placed in the same statistical group (Table 4). In Yozgat, with significant years' averages interactions, S content was greater in the first year (1848.5 mg kg⁻¹) than in the second year (1689.7 mg kg⁻¹) (Table 5).

Combined analyses showed significant differences between the locations and between the cultivars, thus year × location, year × cultivar, location × cultivar and year × location × cultivar interactions were found to be significant (Table 3). As the average of two years, S contents of the

cultivars varied between 1710.9 (Çakır) and 2063.7 (Gökçe) mg kg⁻¹ with an average value of 1857.8 mg kg⁻¹. Just because of differences in cultivar responses to different ecologies, S content was lower in Yozgat (1769.1 mg kg⁻¹) than in Afyonkarahisar (1857.8 mg kg⁻¹) (Table 4). Sulphur is a key component of amino acids (cysteine and methionine), thus a key component of proteins. Biological value of protein is reduced under sulphurous amino acid deficiency (Budag 2009). S contents of chickpea were reported as between 1808.6 - 1848.6 mg kg⁻¹ (Kahraman et al. 2015), between 1790 - 2115 mg kg⁻¹ (Vandemark et al. 2018), and as 1809 mg kg⁻¹ (Ozcan et al. 2013).

CALCIUM (CA) CONTENT

With regard to Ca contents, significant differences were observed between the years and between the cultivars in both locations (Table 3). In Afyonkarahisar, Ca contents of the cultivars varied between 936.2 (Hisar) and 1259.3 (Akça) mg kg⁻¹ with greater Ca content in the first year (1152.4 mg kg⁻¹) than in the second year (956.8 mg kg⁻¹). In Yozgat, Ca contents varied between 1079.0 (Akçin-91) and 1370.2 (Akça) mg kg⁻¹ with lower value in the first year (1015.0 mg kg⁻¹) than in the second year (1365.2 mg kg⁻¹) (Table 4).

Combined analyses showed significant differences between the years, locations and cultivars, year × location and year × location × cultivar interactions were also found to be significant (Table 3). As the average of two years, Ca contents of the cultivars varied between 1013.0 (Hisar) and 1314.8 (Akça) mg kg⁻¹ with a general average of 1122.4 mg kg⁻¹. Ca content was greater in Yozgat (1190.1 mg kg⁻¹) than in Afyonkarahisar (1054.6 mg kg⁻¹) and also greater in the second year (1161.0 mg kg⁻¹) than in the first year (1083.7 mg kg⁻¹) (Tables 4 & 5). It was reported that increasing Ca, Mg, pectin and lignin content of seed coat hindered water intake of the kernels and prolonged cooking durations (Akdag 2001). Seed germination increases with increasing seed calcium contents. In previous studies,

TABLE 5. Average of mineral matter contents of chickpea varieties grown in different years (mg kg⁻¹)

Trails	2015 year			2016 year		
	Afyonkarahisar	Yozgat	Mean	Afyonkarahisar	Yozgat	Mean
K	7695.5	7047.6	7371.5	7761.9	7240.2	7501.0
P	2814.0	2869.5	2799.0	2728.4	2669.1	2741.5
S	1841.0	1848.5	1844.7	1874.5	1689.7	1782.1
Ca	1152.4	1015.0	1083.7	956.8	1365.2	1161.0
Mg	1164.2	1102.6	1060.7	1103.5	957.2	1103.0
Na	574.9	564.3	569.6	528.9	571.3	550.1
Zn	20.84	22.90	21.87	19.06	18.89	18.97
Fe	45.38	42.20	43.79	42.50	44.30	43.40
B	14.57	13.63	14.10	14.03	13.25	13.64
Mn	21.92	16.98	19.38	15.42	13.09	14.25
Cu	7.819	6.755	7.277	6.899	7.141	7.020

chickpea Ca contents varied in a broad range and reported as between 746.8 and 2190.0 mg kg⁻¹ (Alajaji & El-Adawy 2006; Ceran 2015; Haq et al. 2007; Iqbal et al. 2006; Ozcan et al. 2013; Vandemark et al. 2018). Bueckert et al. (2011) carried out a study with 10 chickpea cultivars at two different locations and reported average Ca content as 2036 mg kg⁻¹ in Swift Current location and as 1660 mg kg⁻¹ in Saskatoon location.

MAGNESIUM (MG) CONTENT

With regard to Mg contents, significant differences were observed between the years and cultivars in both locations. Year × cultivar interactions were also found to be significant in both locations (Table 3). In Afyonkarahisar, Mg contents of the cultivars varied between 1024.5 (Hisar) and 1287.4 (Akça) mg kg⁻¹ and the cultivars Yaşa-05 and Işık-05 were placed in the same statistical group with Akça with the greatest Mg content. In Yozgat, Mg contents varied between 890.8 (Azkan) and 1151.6 (Yaşa-05) mg kg⁻¹ and the cultivars Akça, Çakır and Işık-05 were also placed in the same statistical group with Yaşa-05 with the greatest Mg content (Table 4). Mg content of Afyonkarahisar and Yozgat locations was 1164.2 mg kg⁻¹ and 1102.6 mg kg⁻¹, respectively, in the first year and 1103.5 mg kg⁻¹ and 957.2 mg kg⁻¹, respectively, in the second year (Table 5).

Combined analyses showed significant differences in Mg content of the cultivars. Year × location, year × cultivar, location × cultivar and year × location × cultivar interactions were also found to be significant (Table 3). As the average of two years, Mg contents varied between 967.1 (Hisar) and 1189.0 (Yaşa-05) mg kg⁻¹ with a general average of 1081.9 mg kg⁻¹. Mg content was greater in Afyonkarahisar (1133.9 mg kg⁻¹) than in Yozgat (1029.9 mg kg⁻¹) (Table 4). Magnesium plays a significant role in RNA and DNA mechanisms of cell nucleus, protein synthesis and enzyme activity. Legumes generally have quite high magnesium contents (Elinç 2007). In previous studies, Mg contents of chickpeas were reported as between 800 and 2112 mg kg⁻¹ (Bayrak & Onder 2017; Kahraman et al. 2015; Ozcan et al. 2013; Vandemark et al. 2018; Wang et al. 2010).

SODIUM (NA) CONTENT

Significant differences were observed in Na contents of the cultivars in Afyonkarahisar. Year × cultivar interactions were also found to be significant in both locations (Table 3). Na contents varied between 430.2 (Akçin-91) and 786.5 (Akça) mg kg⁻¹ in Afyonkarahisar and between 441.3 (Azkan) and 709.8 (Işık-05) mg kg⁻¹ in Yozgat. The differences in Na content of the years were not found to be significant in both locations (Table 4).

Combined analyses showed significant differences in Na contents of the cultivars. Year × cultivar, location × cultivar and year × location × cultivar interactions were also found to be significant (Table 3). As the average of two years, Na contents of the cultivars varied between

460.5 (Akçin-91) and 714.0 (Akça) mg kg⁻¹ with a general average of 559.9 mg kg⁻¹. The cultivars Yaşa-05 and Işık-05 were also placed in the same statistical group with Akça with the greatest Na content (Table 4). Previous researchers reported average Na content as 960 ppm (Haq et al. 2007), as 1003 ppm (Daur et al. 2008), as 1073.4 ppm (Arab et al. 2010), and as 398.1 mg kg⁻¹ (Ozcan et al. 2013). Such differences were mainly attributed to ecological factors, soil texture, agricultural practices and genetics.

ZINC (ZN) CONTENT

Significant differences were observed in Zn contents of the years and cultivars in both locations. Year × cultivar interactions were also found to be significant in both locations. Zn contents varied between 18.79 (Akça) and 21.15 (Yaşa-05) mg kg⁻¹ in Afyonkarahisar and between 18.88 (Akça) and 25.93 (Işık-05) mg kg⁻¹ in Yozgat location. Zn contents of Afyonkarahisar and Yozgat locations were observed as 20.84 mg kg⁻¹ and 22.90 mg kg⁻¹, respectively, in the first year and as 19.06 mg kg⁻¹ and 18.89 mg kg⁻¹, respectively, in the second year.

Combined analyses showed significant differences in Zn contents of the years and cultivars. Year × location, year × cultivar and year × location × cultivar interactions were also found to be significant (Table 3). As the average of two years, Zn contents of the cultivars varied between 18.84 (Akça) and 23.48 (Işık-05) mg kg⁻¹ with a general average of 20.26 mg kg⁻¹ (Table 4). Average Zn content was 21.87 mg kg⁻¹ in the first year and 18.97 mg kg⁻¹ in the second year (Table 5). Differences between Zn contents of the locations were not found to be significant (Table 4). In previous studies, Zn contents were reported as between 32-42 mg kg⁻¹ (Elinç 2017), between 14-56 mg kg⁻¹ (Alajaji & El-Adawy 2006; Erbaş Köse & Mut 2019; Haq et al. 2007; Kahraman et al. 2015; Mut & Gulumser 1998; Ozcan et al. 2013; Vandemark et al. 2018). Zinc constitutes a building stone of auxin-like hormones effective in plant growth and development (Kaçar 1984). Under zinc deficiency, Tryptophan decreases and protein synthesis is inhibited, thus quality is negatively influenced.

IRON (FE) CONTENT

With regard to Fe contents, significant differences were observed between the years and the cultivars in Afyonkarahisar and between the cultivars in Yozgat. Year × cultivar interactions were found to be significant in both locations (Table 3). In Afyonkarahisar, Fe contents varied between 41.60 (Hisar) and 46.20 (Işık-05) mg kg⁻¹ with a greater value in the first year (45.38 mg kg⁻¹) than in the second year (42.50 mg kg⁻¹). In Yozgat, Fe contents varied between 37.80 (Azkan) and 53.60 (Işık-05) mg kg⁻¹.

Combined analyses showed significant differences in Fe contents of the cultivars. Year × location, year × cultivar, location × cultivar and year × location × cultivar interactions were also found to be significant (Table 3). As the average of the years, Fe contents varied between 40.30

(Hisar) and 49.90 (Işık-05) mg kg⁻¹ with a general average of 46.55 mg kg⁻¹ (Table 4). The differences in Fe contents of the years and the locations were not found to be significant. Chickpea is richer in iron than the other plants and 100 g chickpea meets the entire iron need of a daily diet (Jukanti et al. 2012). Iron also plays a great role in biological nitrogen fixation. In previous studies, Fe contents of chickpeas were reported as between 24.4 and 88.4 mg kg⁻¹ (Haq et al. 2007; Kahraman et al. 2015; Mut & Gulumser 1998; Ozcan et al. 2013), and between 48.4 - 56.5 mg kg⁻¹ (Vandemark et al. 2018). Some others reported average Fe content as 77.2 mg kg⁻¹ (Jukanti et al. 2012), as 29.3 mg kg⁻¹ (Daur et al. 2008), as 68.5 mg kg⁻¹ (Arab et al. 2010) as and 49.5 mg kg⁻¹ (Erbaş Köse & Mut 2019).

BORON (B) CONTENT

With regard to B contents, years, cultivars and year × cultivar interactions were found to be significant in Afyonkarahisar. On the other hand, significant differences were not observed between the cultivars in Yozgat. Year × cultivar interactions were found to be significant in both locations (Table 3). In Afyonkarahisar, B contents varied between 13.47 (Hisar) and 15.27 (Akça) mg kg⁻¹ with a greater value in the first year (14.57 mg kg⁻¹) than in the second year (14.03 mg kg⁻¹). In Yozgat, B contents varied between 12.65 (Azkan) and 14.33 (Akça, Işık-05) mg kg⁻¹ and the differences between the years were not found to be significant (Table 4).

According to combined analyses for B contents, years, locations, cultivars and year × cultivar interactions were found to be significant. Average B contents of the cultivars varied between 13.18 (Hisar) and 14.80 (Akça) mg kg⁻¹ with a general average of 13.83 mg kg⁻¹. Işık-05 cultivar was placed in the same statistical group with Akça cultivar with the greatest B content. With regard to B contents, the first year (14.10 mg kg⁻¹) was greater than the second year (13.64 mg kg⁻¹) (Table 5) and Afyonkarahisar (14.25 mg kg⁻¹) was greater than Yozgat (13.39 mg kg⁻¹) (Table 4). Boron plays a significant role in carbohydrate and protein metabolisms of the plants (Marschner 1995). Kahraman et al. (2015) carried out a study with 10 different chickpea cultivars and reported B contents as between 9.44 - 10.19 mg kg⁻¹; Ozcan et al. (2013) conducted a study with different legume species and reported the average B content of chickpea as 26.4 mg kg⁻¹.

MANGANESE (MN) CONTENT

With regard to Mn contents, significant differences were observed between the years and the cultivars in both locations (Table 3). In Afyonkarahisar, Mn contents varied between 16.80 (Çakır) and 20.95 (Yaşa-05) mg kg⁻¹, the cultivars Akça and Azkan were placed in the same statistical group with Yaşa-05 with the greatest Mn content. In Yozgat, Mn contents varied between 12.83 (Hisar) and 16.68 (Yaşa-05) mg kg⁻¹, the cultivars Çakır and Işık-05

were placed in the same statistical group with Yaşa-05 with the greatest Mn content (Table 4). In both locations, the first year had greater values than the second year (Table 5).

According to combined analyses for Mn contents, years, locations, cultivars, year × location, location × cultivar and year × location × cultivar interactions were found to be significant (Table 3). Average Mn contents of the cultivars varied between 14.88 (Hisar) and 18.82 (Yaşa-05) mg kg⁻¹ with a general average of 16.82 mg kg⁻¹ (Table 4). Mn contents were greater in the first year (19.38 mg kg⁻¹) than in the second year (14.25 mg kg⁻¹) and greater in Afyonkarahisar (18.67 mg kg⁻¹) than in Yozgat (15.04 mg kg⁻¹) (Table 4). Such differences were attributed to better climate conditions of the first year and different responses of the cultivars to ecological conditions. Edible legumes are quite rich in manganese. In previous studies, Mn contents of chickpeas were reported as between 18.5 - 54.5 mg kg⁻¹ (Ceran 2015; Haq et al. 2007; Iqbal et al. 2006; Kahraman et al. 2015; Vandemark et al. 2018).

COPPER (CU) CONTENT

With regard to Cu contents, significant differences were observed between the years and the cultivars in Afyonkarahisar and between the cultivars in Yozgat. Year × cultivar interactions were found to be significant in both locations (Table 3). In Afyonkarahisar, Cu contents varied between 6.738 (Çakır) and 7.903 (Akça) mg kg⁻¹ with greater values in the first year (7.819 mg kg⁻¹) than in the second year (6.899 mg kg⁻¹). In Yozgat, Cu contents varied between 6.170 (Gökçe) and 8.650 (Yaşa-05) mg kg⁻¹ and the differences between the years were not found to be significant (Table 4).

According to combined analyses for Cu contents, cultivars, year × location, year × cultivar, location × cultivar and year × location × cultivar interactions were found to be significant (Table 3). Average Cu contents of the cultivars varied between 6.873 (Çakır) and 8.076 (Yaşa-05) mg kg⁻¹ with a general average of 7.149 mg kg⁻¹ (Table 4). With regard to average Cu contents, the differences between the years and the locations were not found to be significant. Such a case indicated different responses of cultivars to years and locations (Table 3). Copper plays a significant role in protein and carbohydrate metabolisms. It also plays a role in nitrogen fixation. Under copper deficiency, number of bacteroids decrease, leghemoglobin synthesis and nitrogen fixation is inhibited (Gulumser et al. 2008). In previous studies, Cu contents of the chickpeas were reported as between 4.85-14.9 mg kg⁻¹ (Alajaji & El-Adawy 2006; Daur et al. 2008; Haq et al. 2007; Ozcan et al. 2013; Ray et al. 2014).

CORRELATIONS BETWEEN THE INVESTIGATED TRAITS

This study was conducted with eight different chickpea cultivars at two different locations for two years. Correlations between the investigated traits and resultant

TABLE 6. Correlations between seed mineral concentrations for eight chickpea cultivars across two years and two locations

	P	S	Ca	Mg	Na	Zn	Fe	B	Mn	Cu
K	0.820*	-0.674	0.591	0.895**	0.535	0.672	0.871**	0.705	0.820*	0.656
P		-0.494	0.208	0.742*	0.346	0.647	0.811*	0.318	0.857**	0.772*
S			-0.766*	-0.753*	-0.651	-0.595	0.734*	-0.792*	-0.511	-0.403
Ca				0.772*	0.888**	0.224	0.489	0.958**	0.380	0.261
Mg					0.785*	0.455	0.746*	0.796*	0.806*	0.713*
Na						0.087	0.444	0.853**	0.439	0.507
Zn							0.914**	0.278	0.352	0.159
Fe								0.557	0.600	0.449
B									0.512	0.316
Mn										0.783*

K: potassium, P: phosphorus, S: sulfur, Ca: calcium, Mg: magnesium, Na: sodium, Zn: zinc, Fe: iron, B: boron, Mn: manganese, Cu: copper

correlation coefficients are provided in Table 6. K contents had significant positive correlations with P (0.820*), Mg (0.895**), Fe (0.871**) and Mn (0.820*) contents. P contents had significant positive correlations with Mg (0.742*), Fe (0.811*), Mn (0.857**) and Cu (0.772*) contents. S contents had significant positive correlations with Fe (0.734*) content, but had significant negative correlations with Ca (-0.766*), Mg (-0.753*) and B (-0.792*) contents. Ca content has significant positive correlations with Mg (0.772*), Na (0.888**) and B (0.958**) contents; Mg content with Na (0.785*), Fe (0.746*), B (0.796*), Mn (0.806*) and Cu (0.713*) contents; Na content with B (0.853**) content; Zn content with Fe (0.914**) content and Mn content with Cu (0.783*) content.

Bueckert et al. (2011) reported significant negative correlations between chickpea Zn content and Ca (-0.21*) content; significant positive correlations between Fe content and Ca (0.25*) content, between Mg content and

Ca (0.33*) content. Vandemark et al. (2018) reported significant positive correlations of K content with P, S and Zn contents; significant negative correlations of B with Ca, Fe and Mg contents; significant positive correlations of Ca with Fe, Mg and Mn contents; significant negative correlations between P and Zn contents; significant positive correlations of Cu with Mg, Mn, P, Fe, S and Zn contents and significant negative correlations with Cu content; significant positive correlations of S with B, Cu, Fe, Mg, Mn and P contents.

Biplot graph allows researchers to visually present the relationships between the investigated traits. As presented in Figure 1, principle components were able to explain 82.3% total variation (IPCA 1 - 65.0% and IPCA 2 - 17.3%). In biplot graphs, cultivars were gathered under three groups. The first group was composed of Gökçe, Akçin-91, Azkan and Hisar cultivars and they were prominent with their S contents. The second group was composed only of Çakır cultivar and it was stable with regard to all elements.

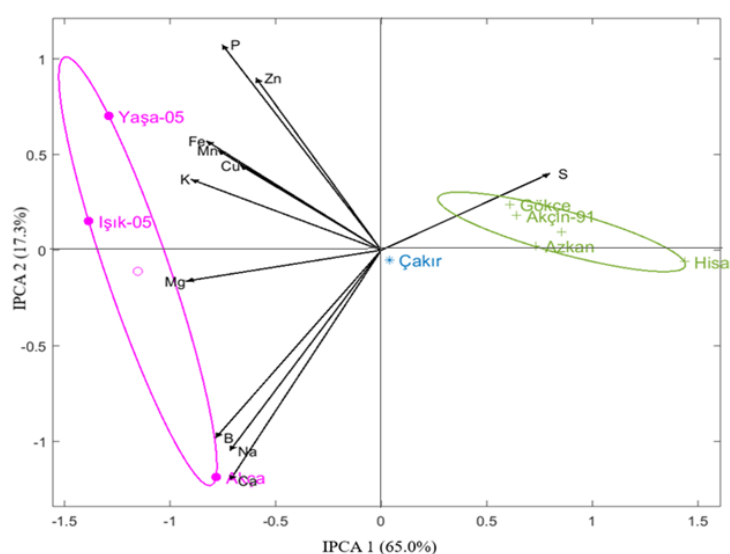


FIGURE 1. Biplot graph showing relationships between minerals and cultivars

The third group was composed of Yaşa-05, Işık-05 and Akça cultivars and they were prominent with the other elements apart from S. In the third group, Akça had better values for B, Na and Ca contents, Yaşa-05 and Işık-05 cultivars had better values for P, Zn, Fe, Cu, Mn, Zn, Mg and K contents.

CONCLUSION

Considering the locations, Afyonkarahisar had greater K, S, Mg, B and Mn contents than Yozgat, but Yozgat was prominent with Ca content. With regard to years on the other hand, 2015 had greater Zn, B and Mn contents, but 2016 had greater Ca content. Such a case was attributed to differences in climate parameters of the locations and the years and differences in soil characteristics of the locations. Locations were not significantly different with regard to P, Na, Zn, Fe and Cu contents and years were not significantly different with regard to K, P, S, Mg, Na, Fe and Cu contents. With regard to average mineral contents of the cultivars, Yaşa-05 cultivar had K, P, S, Mg, Mn and Cu contents greater than the averages and Işık-05 cultivar had greater K, P, Ca, Mg, Na, Zn, Fe and B contents greater than the averages. Except for S, Hisar cultivar had the lowest values for all minerals. Based on location averages, cultivars were gathered under three groups in biplot graph. The first group, composed of Gökçe, Akçin-91, Azkan and Hisar cultivars, was prominent with S content; the second group, composed of Çakır cultivar, was stable for all minerals and the third group, composed of Yaşa-05, Işık-05 and Akça cultivars, was prominent with all elements, except for S. Of the cultivars in the third group, Akça had better outcomes for B, Na and Ca contents, Yaşa-05 and Işık-05 cultivars for P, Zn, Fe, Cu, Mn, Zn, Mg and K contents. It was concluded based on present findings that mineral contents of chickpeas varied based on climate, soil conditions and cultivar genetics.

REFERENCES

- Akdag, C. 2001. Determination of sowing time with chickpea varieties that will provide high yield in Tokat. *JAFAG* 59: 19.
- Alajaji, S.A. & El-Adawy, T. 2006. Nutritional composition of chickpea (*Cicer arietinum* L.) as affected by microwave cooking and other traditional cooking methods. *Journal of Food Composition and Analysis* 19: 806-812.
- Arab, E.A.A., Helmy, I.M.F. & Bareh, G.F. 2010. Nutritional evaluation and functional properties of chickpea (*Cicer arietinum* L.) flour and the improvement of spaghetti produced from its. *Journal of American Science* 6(10): 1055-1072.
- Bayrak, H. & Onder, M. 2017. Determination of agricultural, technological and nutritional characteristics of local populations and varieties of chickpea (*Cicer arietinum* L.) cultivated in Konya ecological region. *Journal of Field Crops Central Research Institute* 26: 52-61.
- Budag, C. 2009. Feed grain legumes and usage in ruminant nutrition. *Yuzuncu Yil University Journal of the Institute of Natural and Applied Sciences* 14(2): 88-101.
- Bueckert, R.A., Thavarajah, P. & Pritchard, J. 2011. Phytic acid and mineral micronutrients in field-grown chickpea (*Cicer arietinum* L.) cultivars from Western Canada. *Eur. Food Res. Technol.* 233(2): 203-212.
- Ceran, F. 2015. Determination of some agricultural characteristics on chickpea (*Cicer arietinum* L.) cultivars that are sown at different periods. PhD Thesis. Selcuk University, Konya, Turkey (Unpublished).
- Daur, I., Khan, I.A. & Jahangir, M. 2008. Nutritional quality of roasted and pressure-cooked chickpea compared to raw (*Cicer arietinum* L.) seeds. *Sarhad J. Agric.* 24(1): 117.
- Elinç, F. 2007. *Plant Nutrition and Soil Fertility*. Ondokuz Mayıs University, Faculty of Agriculture. Textbook. No: 51.
- Erbaş Köse, Ö.D. & Mut, Z. 2019. Determination of mineral content of chickpea varieties and lines grown in Turkey. *Derim.* 36(1): 73-78.
- FAO. 2017. Statistical Databases. <http://faostat.fao.org/site/567/default.aspx#ancor>. Accessed on 1st April 2019.
- Gomez, K.A. & Gomez, A.A. 1984. *Statistical Procedure for Agricultural Research*. 2nd ed. New York: Wiley.
- Gulumser, A., Bozoglu, H. & Peksen, E. 2008. *Edible Legumes*. Ondokuz Mayıs University Agriculture Faculty. Textbook. No: 27.
- Hangen, L. & Bennink, M.R. 2002. Consumption of black beans and navy beans (*Phaseolus vulgaris*) reduced azoxymethane-induced colon cancer in rats. *Nutr. Cancer* 44: 60-65.
- Haq, M.Z.U., Iqbal, S., Shakeel, A., İmran, M., Niaz, A. & Bhanger, M. 2007. Nutritional and compositional study of desi chickpea (*Cicer arietinum* L.) cultivars grown in Punjab. *Pakistan Food Chemistry* 105(4): 1357-1363.
- Iqbal, A., Khalil, I.A., Ateeq, N. & Khan, M.S. 2006. Nutritional quality of important food legumes. *Food Chemistry* 97: 331-335.
- Jukanti, A.K., Gaur, P.M., Gowda, C.L.L. & Chibbar, R.N. 2012. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review. *British Journal of Nutrition* 108(S1): 11-26.
- Kacar, B. 1984. *Plant Nutrition*. AÜ Faculty of Agriculture Publications. Textbook. No: 5090. p. 317.
- Kacar, B. & Katkat, A.V. 1998. *Plant Nutrition*. Uludag University Pub No: 127. Vipaş Press: 3, Bursa.
- Kahraman, A., Ceyhan, E. & Harmankaya, M. 2015. Nutritional variation and drought tolerance in chickpeas (*Cicer arietinum* L.). *J. Elem.* 20(2): 331-341.
- Khetarpaul, N. 2018. Total mineral content present (calcium, magnesium, potassium, phosphorus, iron, zinc, manganese, copper, and boron and nickel) in leaves of Desi and Kabuli chickpea varieties (on dry matter basis). *IJCS* 6(2): 633-635.
- Lee, S.C., Prosky, L. & Devries, J.W. 1992. Determination of total, soluble, and insoluble dietary fibre in foods-enzymatic-gravimetric method, mes-tris buffer: Collaborative study. *Journal of AOAC International* 75: 395-416.
- Marschner, H. 1995. *Mineral Nutrition of Higher Plants*. 2nd ed. New York: Academic Press. pp. 379-396.
- Mut, Z. & Gulumser, A. 1998. The effects of bacteria inoculation, zinc and molybdenum application on some quality traits of Damla-89 chickpea cultivar. *Ondokuz Mayıs University Faculty of Agriculture Journal* 20(2): 1-10.

- Ozcan, M.M., Dursun, N. & Juhaimi, F.A. 2013. Macro-and microelement contents of some legume seeds. *Environ. Monit. Assess.* 185(11): 9295-9298.
- Ray, H., Bett, K., Taran, B., Vandenberg, A., Thavarajah, D. & Warkentin, T. 2014. Mineral micronutrient content of cultivars of field pea, chickpea, common bean, and lentil grown in Saskatchewan, Canada. *Crop Sci.* 54(4): 1698-1708.
- SAS, INC SAS/STAT users' guide release 7.0. 1998. Cary, NC, USA.
- TUIK. 2017. *Agricultural statistics database*. Ankara: Turkish Statistical Institute. www.tuik.gov.tr. Accessed on 1st May 2019.
- Vandemark, G.J., Grusak, M.A. & Mcgee, R.J. 2018. Mineral concentrations of chickpea and lentil cultivars and breeding lines grown in the US Pacific Northwest. *The Crop Journal* 6(3): 253-262.
- Viswanathan, B. & Sudha, K. 1989. Photoelectrochemical properties of platinised TiO₂. *Asian Journal of Chemistry* 1(2): 129.
- Wang, N. & Daun, J.K. 2004. The chemical composition and nutritive value of Canadian pulses. *Canadian Grain Commission*. pp. 19-29.
- Wang, N., Hatcher, D.W., Tyler, R.T., Toews, R. & Gawalko, E.J. 2010. Effect of cooking on the composition of beans (*Phaseolus vulgaris* L.) and chickpeas (*Cicer arietinum* L.). *Food Research International* 43(2): 589-594.
- Wood, A. & Grusak, M.A. 2007. Nutritional value of chickpea. In *Chickpea Breeding and Management*, edited by Yadav, S.S., Redden, B., Chen, W. & Sharma, B. Wallingford, UKC: AB International. pp. 101-142.
- Yalçın, F., Mut, Z. & Erbas Kose, O.D. 2018. Determination of suitable chickpea (*Cicer arietinum* L.) varieties to provide high yield in Afyonkarahisar and Yozgat Conditions. *JAFAG* 35(1): 46-59.

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