DETERMINATION OF SOME QUALITY CRITERIA AND NUTRIENT CONTENTS OF LOCAL BLACK CHICKPEA GENOTYPES GROWTH IN DIFFERENT LOCATIONS

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Abstract. This experiment was conducted in 7 different locations of Turkey (Diyarbakır/Dicle, Malatya, Mardin, Elazığ, Elazığ/Gezin, Iğdır and Hatay) and it was conducted on the black chickpea genotypes. The aim of this experiment is to determine the hydration capacity of black chickpea genotypes, seed ratio with hard seed coat, the weight of one hundred seed, the protein content in the grain, the fat content in the grain and the P, K, Ca, Mo, Fe, Zn, Cu and Mn (mg / kg) contents. In line with this aim, in 2015, it was carried out with three repetitions according to the Trial Plan of Random Parcels. At the end of the experiment, the obtained values were subjected to variance analysis and the differences among the means were tested according to the Duncan multiple comparison method. The difference among the genotypes in terms of hydration capacity was found to be statistically significant at 1%. The hydration capacities of genotypes varied between 0.9826-1.0856. While the genotype of Hatay has the highest hydration capacity, Gezin genotype was determined to have the lowest hydration capacity. In the study, no genotype was found to have seeds with hard seed coat (seed without water). All seeds are swollen as a result of taking water. The highest values were determined as follows: Iğdır genotype with a weight of 12.40 g for the hundred seed, Gezin genotype for the fat ratio in the grain and the ratio of protein in the grain is Elazığ genotype. The Elazığ genotype is prominent in terms of phosphorus, potassium, molybdenum, zinc and copper content in grain.
Keywords: *Cicer arietinum L., cooking time, hydration capacity, macroelements, microelemets*

Introduction

Chickpea (*Cicer arietinum* L.), which belongs to the genus *Cicer* of the family of legumes (Fabaceae), is a legume plant. Almost 10,000 years ago, wheat, barley, rye, peas, vetch and lentil plants together with chickpea, have been reported to be cultivated for the first time in the area called Fertile Crescent (in Turkish: Bereketli Hilal) (Redden and Berger, 2007). The chickpea genus is composed of some perennial species, such as *C. arietinum* L., as well as single-year species. The first chickpea plant cultivated in the area known as the old world is *Cicer arietinum* L. (Tanno and Willcox, 2006). Cultured chickpea *C. arietinum* L. diploid (2n = 16) is an edible legume plant (Sethy et al., 2006). According to a classification, plants in the genus *Cicer* are known to be single or multi-year. According to the morphological characterization, there are 39 species in the genus *Cicer* and after the revision studies, it was reported that *Cicer* genus consists of 44 species, 9 of which are single-year and 35 of which are multi-year (Van der Maesen et al., 2007). Total of 10 species belonging to the genus *Cicer* is located in Turkey and five of them are of endemic character (Öztürk, 2011).

As a result of research with genetic markers, it was detected that the Fertile Crescent Region, which is the homeland of chickpea, is the richest region in terms of chickpea gene sources (Roorkiwal et al., 2014). Chickpea taxa shows to be most spread in Turkey in the following regions: Southeast Anatolia, Mediterranean, Eastern Anatolia and Aegean regions. The species spread in Turkey are: *C. arietinum*, *C. reticulatum*, *C. echinospermum*, *C. pinnatifidum*, *C. bijugum*, *C. incisum*, *C. montbretii*, *C. floribundum*, *C. isauricum*, *C. heterophyllum*, *C. uluderensis* and *C. anatolicum* türleridir (Van der Maesen, 1972; Öztürk, 2011; Akın, 2018) (*Fig. 1*).

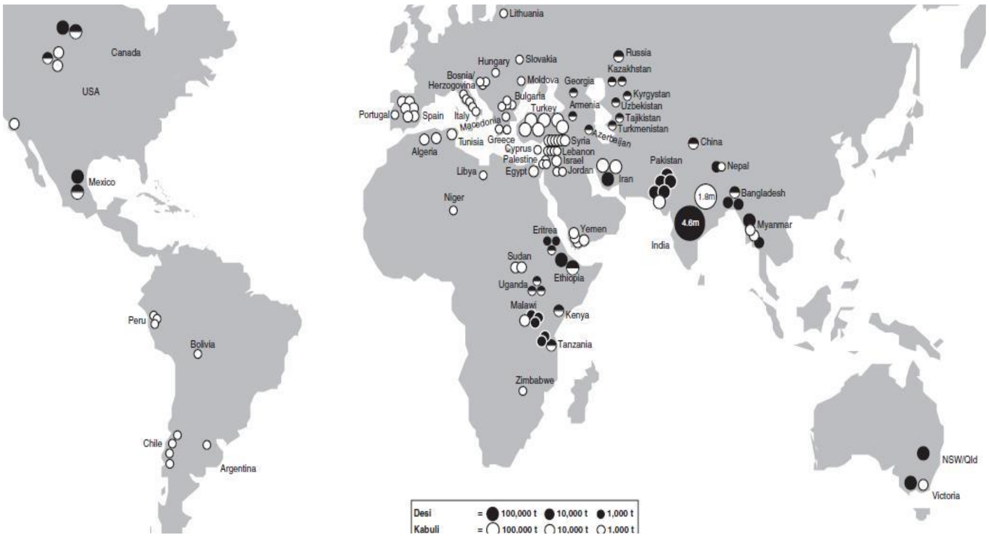

Figure 1. *Kabuli and Desi type chickpea production pattern of the world (Knights et al., 2007)*

Legumes contain high protein, low fat content, vitamins and minerals as nutritional values in their seeds (Pekşen and Artık, 2005). In addition, edible legumes contain 11% of insoluble dietary fibers that are beneficial for intestinal health due to their laxative effects (Anderson and Bryant, 1986; Marlett et al., 2002). Chickpea seed coat was found to be rich in dietary fiber and minerals. However, the contribution of the seed coat on nutritional benefits of the whole seed were determined to be limited (Savar and Karataş, 2017). If the benefits of chickpea in human nutrition are listed; Polyphenols are common constituents of foods of plant origin and major antioxidants in the human diet. These compounds possess diverse biological activities such as antioxidation, apoptosis, antiaging, anticancer, antiinflammation, antiatherosclerosis, cardiovascular protection, improvement of the endothelial function, as well as inhibition of angiogenesis and cell proliferation activity (Ozdemir, 2006; Han et al., 2007). Colored seeds contained up to 13-, 11-, and 31-fold more TPC (Total polyphenol content), TFC (Total flavonoid content), and antioxidant activity, respectively, than cream- and beige-color seeds. Thus, colored chickpea could be a potentially functional food in addition to its traditional role of providing dietary proteins and dietary fibers. colored chickpea might be considered a functional food in addition to its traditional role of providing dietary proteins. Colored chickpea might also contribute significantly to the management and/or prevention of degenerative diseases associated with free radical damage due to their high antioxidant activity. Due to their high antioxidant activity, future research should be conducted to verify that colored chickpeas can be used for management and/or prevention of degenerative disease (Segev et al., 2010).

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While chickpea is the second most sown and farmed legume in the world among the edible legumes, it is ranked first in our country (Anonymous, 2016). While India ranks first in terms of cultivation area and production, 2/3 part of the world chickpea production takes place in this country. In terms of cultivation area Turkey is fourth after Pakistan and Iran and third in terms of production.

According to the studies conducted, *Cicer* species in the flora of Turkey (Davis et al., 1988) was represented by 9 species. With the work done in the following years *C. uluderensis* (Dönmez, 2011), *C. reticulatum* (Ladizinsky, 1975) and *C. heterophyllum* (Constandriopoulos et al., 1972) species were identified in Turkey and had been added to the world scientific literature as new species. On the other hand; *C. floribundum* var. *Amanicola* in Osmaniye, *C. heterophyllum* var. *Kasanii* in Antalya and *C. incisum* subsp. *Serpentinica* in Erzincan are introduced to the scientific world with relevant study (Öztürk, 2011) and the total number of taxa spreading in Turkey increased to 15. This study conducted on chickpea plant which has been spreading widely in Turkey, showed that it is crucial to reserve the black chickpea as a genetic resource due to its resistance to diseases and adverse environmental conditions, quality parameters and active substances.

In this study, it is aimed to emphasize the importance of black chickpea, which is rarely grown and scarcely found in our country and to restore it to agriculture and human life by looking at some quality criteria and nutrient element contents.

Literature review

It is known that black chickpea which belongs to the Desi variety, also known as Bengal Gram in India, has high fiber content and low glycemic. In India, black chickpeas are highly involved in human nutrition. Black chickpea is not given the necessary importance in our country. Black chickpea, which is important in the eating habits of our ancestors, has lost its importance today and has even been used as animal feed by producers. Today, the cultivation of black chickpea covers a very small area and cannot be evaluated statistically. Black chickpea, which had been produced in the past years, is now being produced by some farmers in regions such as Malatya, Elazığ, Elazığ/Gezin, Diyarbakır/Dicle, Mardin, Iğdır and Hatay. This production is done to meet the farmer's own needs and is usually given as supplementary food in animal feed.

Yarmaca and mekaşer are local food names of Eastern Anatolia. As well as being directly used in food, black chickpea is also used as ‘yarmaca’ and ‘mekaşer’ after being put through certain processes. Black chickpeas are more delicious than other chickpeas. Black chickpea is a versatile legume and is widely used in India and the Middle East. It is consumed as a fast snack in meals, humus and curries, soups and salads in Turkey.

It is produced by some farmers in regions such as Malatya, Elazığ, Elazığ/Gezin, Mardin, Diyarbakır/Dicle, Iğdır, Hatay and is consumed by a certain part of the population and finds buyers at very high prices. They are either put into food after being boiled or are added into food as yarmaca (Malatya region) or mekaşer (Diyarbakır-Dicle region) after certain processes and consumed that way. In contrast to the positive aspects of food legumes such as high protein content, the length of cooking times is seen as a negation for their consumption. It was observed that the cooking time was closely related to the hydration capacity of the seed and that there was a positive relationship between the hydration capacity and the cooking time and that the varieties with high hydration capacity were more rapidly cooked (Williams et al., 1983; Manan et

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al., 1987; Singh et al., 1991). For this reason, it has been tried to increase the hydration capacity of seed with various breeding and growing techniques in edible legumes (Rao and Vakil, 1985).

Materials and methods

Material

Black chickpeas obtained from Diyarbakır / Dicle, Malatya, Mardin, Elazığ, Elazığ / Gezin, Iğdır and Hatay were used in the experiment.

All genotypes have taken their names from the provinces and districts where situated in South East, Meditereinan and Eastern Anatolia regions of Turkey. All collected genotypes were grown with the same methods without fertilization in dry conditions. The aim of the study is to determine the nutrient content of genotypes grown under farmer conditions. 1 kg of samples were collected from each genotype. Materials were obtained from seeds grown by farmers in traditional methods.

Methods

The study was carried out with three repetitions according to the Trial Plan of Random Parcels.

Determination of hydration capacity, hard seed coat and hydration index (%)

In the study, seed weight was detected by weighing 50 seeds from each genotype and these seeds were placed in a 250 ml erlenmayer with a wide mouth then 100 ml demineralized water was added to the seeds and the mouth of the erlenmayer was covered with aluminum foil for 16 hours at room temperature (22-25°C). Seeds that were kept at room temperature for 16 hours were taken from the containers at the end of this period and were kept for a short time between drying papers in order to remove the water on them. Then, if there had been non-swelling seeds, they were separated as hard-coated seeds and the hydration capacities and hydration indices of the varieties were determined after various calculations were made by weighing the wet weights of the remaining seeds. The following equation was used to determine the hydration capacity. Hydration index was also determined by calculating the hydration capacity against the original seed weight (Williams et al., 1986) (*Eq. 1*).

$$Hydration\ Capacity = \frac{Y-\left(X-\left(\frac{X}{100}\right)N2\right)}{N1-N2} \quad \text{(Eq.1)}$$

where

- Y = Wet Seed Weight.
- X = Dry Seed Weight.
- N_1 = Original Seed Count.
- N_2 = Hard-Coated Seed Count (Non-Water Drawing Seed Count).

Weight of one hundred seed, (g)

The grains were randomly weighed in four groups of 100 pieces, on a 0.01 g sensitive scale, and averages of one hundred seed, were calculated.

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Grain protein ratio (%)

After grinding the seeds, Kjeldahl method was applied and the amount of nitrogen was determined, and the resulting values were multiplied by 6.25 and the crude protein ratios in the grains of genotypes were detected.

Fat content in grain (%)

Spectra Star laboratory type NIR (Near Infrared) analyzer was used to determine the crude fat content in the grains of genotypes.

Determination of macro and micro nutrients in seeds

Phosphorus content in grain (%) was calculated according to Kacar (1984), with vanado molybdo phosphoric acid yellow color method. Mo, Fe, K, Ca, Zn, Cu and Mn (mg / kg) analyses were performed according to Kacar (1994).

At the end of the study, the obtained values were subjected to variance analysis and the differences among the means were tested according to Duncan's multiple comparison method ($P < 0.05$). In statistical analysis, information from Yurtsever (1984) and Düzgüneş et al. (1987) were used.

Results and discussions

The Duncan groups are shown in *Table 1*, which gives us the mean values of the weight of one hundred seed, protein content in the grain, fat content in the grain, hydration capacity, hydration index and the differences among the means belonging to the black chickpea genotypes grown in different locations in Turkey.

The weight of one hundred seed, is a genre specification and it shows significant changes compared to genotypes. As shown in *Table 1*, the average weight of one hundred seed, of genotypes used in the study ranged from 7.97-12.40 g. The lowest hundred seed weight was obtained from the Dicle genotype and the highest value was obtained from the Iğdır genotype. Karaköy (2008) reported that the weight of one hundred seed, of chickpeas varied between 37.6-51.5 g. The findings of this study were different with the findings of the researchers. The reason for this is that the black chickpeas used in this study have smaller grain size than the other chickpeas and they are not developed by any reclamation method.

The mean hydration capacity of the genotypes used in the study ranged between 0.9826-1.0856 g/seed and the lowest hydration capacity was detected in the Gezin genotype, but its difference from the Malatya genotype was not statistically significant. The highest hydration capacity was obtained from Hatay genotype and its difference compared to Mardin and Elazığ genotypes was statistically insignificant. In previous studies, it had been reported that the water absorption properties of legume seeds are related to seed size and seed coat thickness (Kaur et al., 2005). Toğay et al. (2001) stated in their study conducted within the chickpea varieties that have been registered in Turkey that the hydration capacity varies between 0.979-1.223 g/seed. In terms of this feature, the findings of the researchers seem to be supporting each other. In a study, unlike these research findings, the hydration capacity in Desi genus chickpea grown in Tunisia was found to be 0.64 g/seed (Ghribi et al., 2015).

As can be seen from *Table 1* the mean hydration index of the genotypes used in the study ranged from 16.23 to 23.66% and the lowest hydration index was obtained from

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the Iğdır genotype but the difference between it and the Gezin genotype was statistically insignificant. The highest hydration index was obtained from the Dicle genotype. In this study, no statistical analysis was performed since there were no genotypes with hard seed coat among black chickpea genotypes. Considering the positive relationship between hydration capacity and cooking time reported in the previous studies regarding this topic (Williams et al., 1983; Manan et al., 1987; Singh et al., 1991), the Hatay genotype has been found to be more suitable for rapid cooking than the other varieties. The Gezin black chickpea genotype can be evaluated as the longest cooking type.

Table 1. *Duncan groups showing the average values and the differences among means of the weight of one hundred seed, hydration capacity, hydration index, protein content in the grain and fat content in the grain of the black chickpea genotypes grown in different locations in Turkey*

Genotypes	Weight of one hundred seed (g)*	Hydration capacity (g/seed)**	Hydration index (%)*	Protein content in the grain (%)*	Fat content in the grain (%)*
Dicle	7.97 d	1.0493 ab	23.66 a	19.60 c	3.25 c
Malatya	9.58 c	0.9986 c	21.30 b	19.58 c	3.17 c
Mardin	11.27 b	1.0583 a	18.56 c	19.75 c	3.20 c
Elazığ	10.98 b	1.0650 a	18.66 c	22.54 a	3.21 c
Gezin	11.55 ab	0.9826 c	16.50 d	19.91 c	3.55 a
Iğdır	12.40 a	1.0121 bc	16.23 d	19.33 c	3.37 b
Hatay	10.81 b	1.0856 a	19.53 c	20.83 b	2.93 d

**: $p<0.01$; *: $p<0.05$

The average protein content of the genotypes was varying between 19.33-22.54% and the lowest protein ratio was obtained from the Iğdır genotype, but the difference among it and the Dicle, Malatya, Mardin and Gezin genotypes was not statistically significant. The highest protein ratio in the grain was obtained from Elazığ genotype. Dry seed protein rate was stated to be between 12.4% and 31.5% (average 23%) (Özdemir, 2006). Dinç (2014) carried out an adaptation work with the chickpea varieties were registered in Turkey and the protein content in grain values were reported to vary between 20.32-24.5%. As a result of this study, the protein ratio values in the grain were found to be close to the values reached by different researchers like (Khan et al., 1995; Önder and Üçer, 1999; Erdin and Kulaz, 2014).

As it was seen on *Table 1*, the average fat content of genotypes in the study was 2.93-3.55% and the lowest fat content was obtained from Hatay genotype while the highest ratio was obtained from Gezin genotype. Özdemir (2006) stated the rate of the oil in chickpea seeds range between 3.8-12.2% and among the edible legumes, most oil was to be found in chickpeas. Şehirali (1988a) had reported that the fat content of chickpeas ranged from 1.5-6.8% while the adaptation study conducted by Dinç (2014) with the chickpea varieties which have been registered in Turkey, stated that the fat content in the grain varied between 4.01-4.93%. The low-fat content of black chickpea compared to other chickpeas is very important for low calorie nutrition and especially for cardiovascular diseases and cholesterol.

Duncan groups showing the mean values and the difference among mean values of black chickpea genotypes grown in different locations of Turkey in terms of iron,

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molybdenum, manganese, copper and zinc content are shown in *Table 2*. Duncan groups showing the mean values and the differences among the mean values obtained in terms of calcium, phosphorus and potassium content are shown in *Table 3*.

Table 2. *Duncan groups showing the mean values and the difference among mean values of black chickpea genotypes grown in different locations of Turkey in terms of iron, molybdenum, manganese, manganese, copper and zinc content*

Genotypes	Iron Content (ppm)*	Molybdenum content (ppm)**	Manganese content (ppm)*	Copper content (ppm)*	Zinc content (ppm)*
Dicle	50.15 c	2.36 bc	23.62 d	15.06 ab	58.58 b
Malatya	73.20 a	2.30 cd	30.27 c	15.81 a	46.59 bc
Mardin	43.20 cd	2.16 d	25.27 d	12.76 c	40.10 c
Elazığ	47.09 cd	2.50 ab	41.33 b	15.58 a	96.33 a
Gezin	61.69 b	2.43 abc	27.86 cd	13.52 bc	35.36 c
Iğdır	40.67 d	2.43 abc	28.13 cd	12.76 c	36.49 c
Hatay	49.45 cd	2.60 a	46.00 a	12.58 c	32.40 c

**: $p<0.01$; *: $p<0.05$

As shown in *Table 2*, the iron content of the genotypes used in the study ranged from 40.67-73.20 ppm and the lowest iron content was obtained from Iğdır genotype, while the highest iron content was obtained from Malatya genotype. Özdemir (2006) reported that an average of 6.6 mg (66 ppm) iron mineral exists in 100 gr seed. The iron content of black chickpea was also found to be within the average of iron content of other chickpeas. Due to the high iron and calcium content of chickpea, it is especially recommended for preschool children, pregnant and lactating women.

The effect of black chickpea genotypes on molybdenum content in grain was statistically significant at 1% level. Average molybdenum content of the genotypes used in the study ranged from 2.16 to 2.60 ppm and the lowest molybdenum content was obtained from the Mardin genotype, while the highest molybdenum content in the grain was obtained from the Hatay genotype.

The manganese content of the genotypes used in the experiment varied between 23.62-46.00 ppm and the lowest manganese content was obtained from the Dicle genotype. Its difference from Mardin genotype was statistically insignificant. Mut and Gülümser (2005) stated that manganese content varies between 19-20.42 ppm in zinc and molybdenum applications with bacterial inoculation in chickpea. The manganese content of black chickpea which had not been subjected to any fertilizer application, was even higher than the normal average rate of chickpea.

As shown in *Table 2*, the average copper content in the grain of genotypes used in the study ranged from 12.58 to 15.81 ppm, while the lowest copper content was obtained from the Hatay genotype, its difference compared to the Iğdır and Mardin genotypes were found to be statistically insignificant. The highest copper content in grain was obtained from Malatya genotype but its difference from Elazığ genotype was found to be statistically insignificant. Mut and Gülümser (2005) stated that the copper content of zinc and molybdenum applied together with bacterial vaccination in chickpea ranged between 10-11.67 ppm on average in studies. In the study conducted by the

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researchers, it is believed that the low content of manganese and copper is due to the applied zinc fertilizer.

The mean zinc content of the genotypes used in the study changed between 32.40-96.33 ppm and the lowest zinc content was obtained from Hatay genotype. Its difference from Iğdır, Gezin and Mardin genotypes was found to be statistically insignificant. The highest zinc content in grain was obtained from Elazığ genotype. Legumes are rich in zinc content and chickpea is reported to contain an average of 3.4 mg of zinc (Anonymous, 2015). It was observed in this study that zinc content of black chickpea is also quite high.

As can be seen in *Table 3*, the calcium content of the genotypes used in the study varies between 0.28-0.58%. Even though the lowest calcium content was obtained from Dicle genotype, the difference between it and Elazığ genotype was statistically insignificant. The highest calcium content in grain was obtained from Mardin genotype. Özdemir (2006) reported that the average calcium content in 100 gr seed is 185.6 mg (0.185%) while Şehirali (1988b) stated that there were 33-1980 mg of calcium in 100 grams of chickpea.

Table 3. *Duncan groups showing the mean values and the difference among mean values of black chickpea genotypes grown in different locations of Turkey in terms of calcium, phosphorus and potassium content*

Genotypes	**Calcium content (%)***	**Phosphorus Content (%)***	**Potassium Content (%)***
Dicle	0.28 c	0.33 c	1.13 bc
Malatya	0.32 bc	0.28 d	1.02 cd
Mardin	0.58 a	0.29 d	1.00 d
Elazığ	0.31 c	0.42 a	1.20 ab
Gezin	0.45 b	0.43 a	1.30 a
Iğdır	0.35 bc	0.34 bc	0.97 d
Hatay	0.40 bc	0.36 b	1.25 a

*: $p<0.05$

The phosphorus content of the genotypes used in the experiment changed between 0.28-0.43% and the lowest phosphorus content was obtained from Malatya genotype but the difference between it and Mardin genotype was found statistically insignificant. The highest phosphorus content in grain was obtained from Gezin genotype and its difference from Elazığ genotype was not statistically significant. Özdemir (2006) reported that the phosphorus content in chickpea was 342.9 mg (0.34%) in 100 gr seed. The phosphorus content of black chickpea also appears to be around average values.

As shown in *Table 3*, the potassium content of the genotypes used in the study ranged from 0.97% to 1.30% and the lowest potassium content was obtained from the Iğdır genotype and the difference between it and the Mardin genotype was found to be statistically insignificant. The highest potassium content in grain was obtained from the Gezin genotype and the Hatay genotype was also in the same group.

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Conclusion

The hydration capacity, which is an important criterion in chickpea consumption, was measured in studied chickpea genotypes. In genotypes with low hydration capacity, water is absorbed in a long time and the duration of cooking of seeds is increased. Hard seed crusted seeds cannot absorb water as fast as normal seeds, cannot germinate or cook quickly. As a result of this study, it was detected that the best black chickpea genotypes are the Hatay and Elazığ genotypes in terms of hydration capacity and cooking characteristics. These genotypes are good sources of genes with respect to their hydration capacity during breeding work. In addition, the resistance to anthracnose, which is known to be the most important factor limiting yield in chickpeas, especially in early planting and in areas with high humidity, should be considered. Elazığ genotype is prominent in terms of fat content in the grain, protein content in the grain, phosphorus, potassium, molybdenum, zinc and copper content. In terms of healthy eating; black chickpea has a high protein content, low fat content and rich in especially calcium, iron and zinc. In this way, it is very important that it regains its rightful place by taking part in nutrition programs.

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