YYÜ TAR BİL DERG
(YYU J AGR SCI)
2018, 28(1): 55-61

Geliş tarihi (Received): 19.10.2017
Kabul tarihi (Accepted): 10.02.2018
doi: 10.29133/yyutbd.345154

Araştırma Makalesi/*Research Article (Original Paper)*

Quality Traits of Green Lentil (*Lens culinaris* Medik.) Cultivars and Lines

Özge Doğanay ERBAŞ KÖSE[1*], Hatice BOZOĞLU[2], Zeki MUT[1]

[1] Bozok University, Faculty of Agriculture, Departmant of Field Crops, Yozgat, Turkey
[2] Ondokuz Mayis University, Faculty of Agriculture, Departmant of Field Crops, Samsun, Turkey
*e-mail: ozgedoganay.erbas@bozok.edu.tr, Tel: +90 354 242 1028/4466; Fax: +90 354 242 10 96

Abstract: This study was conducted to determine mineral composition (K, Ca, Mg, Cu, Fe, Mn, Mo and Zn) and some other quality traits of 9 different lentil cultivars and lines under Yozgat conditions between the years 2014-2016. Experiments were conducted in randomized complete block designs with 3 replications. As the average of the years, ash ratios of the cultivars and lines varied between 2.87-3.56%, protein ratios between 27.3-31.2%, starch ratios between 45.1-47.3%, amylose ratios between 10.7-12.9%, K contents between 786.3-904.7 mg $100g^{-1}$, Ca contents between 75.2-84.7 mg $100g^{-1}$, Mg contents between 66.2-78.5 mg $100g^{-1}$, Cu contents between 0.76-1.01 mg $100g^{-1}$, Fe contents between 5.49-7.19 mg $100g^{-1}$, Mn contents between 1.11-1.50 mg $100g^{-1}$, Zn contents between 3.63-3.97 mg $100g^{-1}$, Mo contents between 0.30-0.38 mg $100g^{-1}$, thousand grain weights between 32.4-55.1 g, seed coat ratio between 8.30-9.23%, water absorption capacity between 0.032-0.064 g $seed^{-1}$, swelling capacities between 0.023-0.055 ml $seed^{-1}$, unit volume weight between 1.05-1.30 g ml^{-1} and hydration capacities between 98.5-117.65. Among the investigated genotypes, Local 1 was prominent with desired quality attributes.

Keywords: Green lentil, Mineral matter, Quality characteristics

Yeşil Mercimek (*Lens culinaris* Medik.) Çeşit ve Hatlarının Kalite Özellikleri

Özet: Bu çalışma, Yozgat koşullarında 9 farklı mercimek çeşit ve hatlarının bazı kalite özellikleri ile mineral içeriklerini (K, Ca, Mg, Cu, Fe, Mn, Mo ve Zn) belirlemek amacıyla 2014-2016 yılları arasında yürütülmüştür. Deneme tesadüf blokları deneme desenine göre üç tekrarlamalı olarak gerçekleştirilmiştir. İki yılın ortalamasına göre çeşitlerin ve hatların kül oranı % 2.87 ile 3.56, protein oranı % 27.3 ile 31.2, nişasta oranı % 45.1 ile 47.3, amiloz oranı % 10.7 ile 12.9, K içeriği 786.3 ile 904.7 mg/100g, Ca içeriği 75.2 ile 84.7 mg/100g, Mg içeriği 66.2 ile 78.5 mg/100g, Cu içeriği 0.76 ile 1.01 mg/100g, Fe içeriği 5.49 ile 7.19 mg/100g, Mn içeriği 1.11 ile 1.50 mg/100g, Zn içeriği 3.63 ile 3.97 mg/100g, Mo içeriği 0.30 ile 0.38 mg/100g, bin tane ağırlığı 32.4 g ile 55.1 g, kabuk oranı % 8.30 ile 9.23, su alma kapasitesi 0.032 ile 0.064 g/tane, şişme kapasitesi 0.023 ile 0.055 ml/tane, birim hacim ağırlığı 1.05 ile 1.30 g/ml, hidrasyon kapasitesi % 98.5 ile 117.6 arasında değişmiştir. Yerel 1 hattı istenilen özellikler bakımından ön plana çıkmıştır.

Anahtar kelime: Yeşil mercimek, Mineral madde, Kalite özellikleri

Introduction

Lentil belongs to *Leguminosae* family. It is a diploid annual pulse crop with 2n=14 chromosomes. Lentil is grown over sub-tropical and temperate climate zones between 58° North and 40° South latitudes (Alghamdi et al. 2014). It is grown in almost every region (except for eastern Black Sea region) of Turkey. Turkey is located within Mediterranean and Near East gen centers for large and medium size seeds (Şehirali 1988). Lentil is cultivated over 4.5 million ha lands area worldwide and annual production is around 4.8 million tons. Turkey with 360 thousand tons of production meets about 7% of world lentil production and has the third place in world lentil production after India and Canada (FAO 2014). Lentil is more preferred over the other grain legumes in human nutrition because of low level of nutrition-hindering factors, high protein content and shorter cooking duration than the other grain legumes (Coşkuner and Karababa 1998; Kaya 2010). With 25% protein content, lentil has the second greatest protein content after soybean (Kaya 2010). Lentil is also quite rich in soluble and insoluble fiber, vitamins, minerals (sodium (Na), copper (Cu), potassium (K), magnesium (Mg), phosphorus (P), calcium (Ca), iron (Fe), manganese (Mn) and zinc (Zn)) and antioxidant compounds (Urbano et al. 2007; Yadav et al. 2007). Colon cancer, diabetes, hemorrhoid, cardiovascular diseases and obesity-like diseases are all resulted mostly from less consumption of fibrous foods (Trowell et al. 1985). Therefore, consumption of lentil-like highly

fibrous grain legumes may allow human metabolism to have a healthy structure and reduce the risk of above-mentioned diseases.

Lentil has a significant place in Turkish agriculture. Red lentils are produced mostly in Southeastern Anatolia region as winter-sown and green lentils are produced in Central Anatolia and transition regions as summer-sown. Some recently registered green lentil cultivars are also produced as winter-sown even in regions with quite harsh winter conditions (Aydogan et al. 2008). Green lentils are produced in 40 provinces of Turkey. Yozgat province has the largest production area and it is followed by the provinces of Corum, Kırıkkale, Ankara, Manisa, Kırsehir and Konya, respectively (TUIK 2016).

In this study, some physical and chemical characteristics (ash, protein, starch and amylose ratios, thousand seed weight, husk ratio, water intake capacity, swelling capacity and bulk density) and mineral contents (K, Ca, Mg, Cu, Fe, Mn, Mo and Zn) of 9 different lentil cultivar and lines were determined.

Materials and Methods

Experiments were conducted over the experimental fields of Agricultural Research and Implementation Center of Bozok University under Yozgat provincial conditions during 2014-2016 growing seasons for 2 years. Five winter-sown lentil cultivars (Pul 11, Ceren, Ankara Yesili, Yusufhan, Kayı 91) supplied from Field Crops Central Research Center and 4 local lentil lines collected from the region were used as the plant material of the study. Sowing dates were 21th October 2014 and 3th November 2015, respectively. The seed were planted using an experimental drill in 1.2 × 4 m plots consisting of six row with 20 cm row space. Harvest dates were 17th July 2015 and 23th July 2016, respectively. For seed ash, protein and starch contents and mineral composition analyses, 100 g seed was ground in a seed mill. Analyses were performed with sufficient amount of ground seeds. Protein analyses were performed with Kjeldahl method, starch analyses with Ewers Polarimetric enzymatic methods (AOAC 2005); physico-chemical characteristics were determined in accordance with the methods specified by Karayel (2012) and Zia-ul-Haq et al. (2007); seed mineral contents were determined with Atomic Absorption Spectroscopy device (Kesli 2009; Kaya 2010; Karayel 2012). Experimental results were subjected to variance analysis with SAS statistical software in accordance with randomized complete block design with three replicates (SAS 1998). Differences between cultivars and lines means were identified with Least Significant Difference (LSD) test. Biplot analysis was performed with Biplot Macro add-in of Microsoft Excel (Lipkovich and Smith 2002).

Results and Discussion

Combined (two-year) analysis results revealed that years, cultivars and lines cultivars and lines and year x cultivars/lines interactions had significant effects on seed ash contents of the cultivars and lines ($p<0.01$) (Table 1). Ash ratios of the cultivars and lines varied between 2.87% (Ceren) and 3.56% (Local 2) with an average value of 3.09%. Ash ratios of the first year were higher than the second year (Table 1). Ash content of lentil seeds was reported as between 3 and 5% by Padovani et al. (2007), as 2.7% by Shahwar et al. (2017) and such value were higher than ash contents of other grain legumes (Ryne et al. 2007; Ezzar Fariz et al. 2013).

With regard to protein ratios of the cultivars and lines, combined results revealed significant effects of the years ($p<0.01$), genotypes ($p<0.01$) and year x cultivars/lines interactions ($p<0.05$). In combined years, protein ratios of the cultivars and lines varied between 27.3% (Ankara Yesili) and 31.2% (Local 2) with an average value of 29.2%. The lines Local 2 with the greatest protein ratio was placed in the same statistical group with Local 1 line. Average protein ratio of the cultivars and lines was higher in the second year (30.1%) than in the first year (28.3%) (Table 1). In previous studies, protein ratios of lentil seeds were reported as between 25.3 - 29.0% (Alghamdi et al. 2014) and as between 22.79 - 29.735 (Kahraman 2016). Just because of high protein ratios, lentils and other pulse crops are greatly placed in diets of low-income people especially of developing countries (Hoover et al. 2010).

Considering the combined results on starch ratios, it was observed that years ($p<0.01$) and cultivars/lines ($p<0.05$) had significant effects on starch ratios of the cultivars and lines, and the effects of year x cultivar/ line interactions were not found to be significant. As the average of the years, starch ratios varied between 45.1% (Local 1) and 47.3% (Ankara Yesili) with an average value of 46.3%. The cultivar Ankara Yesili (47.3%) with the greatest starch ratio was placed in the same statistical group with the cultivar Yusufhan (47.2%), the line Local 3 (46.9%), the cultivars Ceren (46.7%) and Kayı 91 (46.3%). The starch ratio of second year (47.4%) was higher than the first year (45.1%) (Table 1). Carbohydrates are the principle component of lentil seeds. Therefore,

with a great starch ratio (47.1%), lentils are the second pulse crops among the legumes (Shahvar et al. 2017). In previous studies, starch ratios of lentil seeds were reported as between 44.3 - 47.0% (Wang 2008) and as between 38.3 - 54.0% (Kaya 2010).

With regard to combined analyses results on amylose ratios, it was observed that genotypes had significant effects on amylose ratios of the cultivars and lines ($p<0.05$), but the effects of years and year x cultivar/line interactions were not found to be significant. As the average of the years, amylose ratios of the cultivars and lines varied between 10.7% (Local 1) and 12.9% (Yusufhan) with an average value of 11.9%. The cultivars Pul 11, Ceren, Ankara Yesili and Kayı 91 were placed in the same statistical group with the cultivar Yusufhan with the greatest amylose ratio (Table 1). Amylose ratios of lentil seeds were previously reported as between 13.3-14.0% by Sandhu and Lim (2008) and as between 13.3-14.5% by Chung et al. (2008) and researchers observed significant differences in protein, starch and amylose contents of the genotypes and cultivars.

Table 1. Chemical properties of lentil cultivars and lines (%)

Cultivars /Lines^{+}	Ash ratio	Protein ratio	Starch ratio	Amylose ratio
Pul 11	2.99 e	29.3 bc	45.5 c	12.6 ab
Ceren	2.87 f	28.7 bcd	46.7 ab	11.9 a-d
Ankara Yesili	2.81 g	27.3 e	47.3 a	12.3 abc
Yusufhan	3.00 e	28.2 de	47.2 a	12.9 a
Kayı 91	3.06 d	29.3 bc	46.3 abc	12.5 abc
Local 1	3.89 f	31.2 a	45.1 c	10.7 d
Local 2	3.56 a	30.5 a	45.5 c	11.5 bcd
Local 3	3.37 b	28.4 cd	46.9 ab	11.4 bcd
Local 4	3.25 c	29.4 b	45.8 bc	11.3 cd
Mean	3.09	29.2	46.3	11.9
Years				
2014-2015	3.23 A	28.3 B	45.1 B	11.7
2015-2016	2.95 B	30.1 A	47.4 A	12.0
Year (Y)	**	**	**	ns
Cultivar/Lines (G)	**	**	*	*
Y×G	**	*	ns	ns
CV (%)	1.13	2.85	2.22	2.17

*Significant at P≤0.05;**Significant at P≤0.01; ns- Non Significant at P > 0.05; $^{+}$The difference between the averages shown with the same letters is not significant at the 5% level.

Significant differences ($p<0.01$) were observed for K, Ca, Mg, Fe, Mn and Zn content between years while the effect of genotype was significant ($p<0.05$) on K, Ca, Mg and Mn contents. The differences in Cu and Mo contents of the years and Fe, Zn and Mo contents of the cultivars and lines were not found to be significant. Also, the effects of year x cultivar/ line interactions on mineral contents were not found to be significant (Table 2). In combined years, the variation among genotypes was between K contents 786.3 (Local 3) and 904.7 mg/100g (Local 1), for Ca contents 75.2 (Local 3) and 84.7 mg/100g (Local 1), for Mg contents 66.2 (Local 3) and 78.5 mg/100g (Local 1), for Cu contents 0.76 (Local 3) and 1.01 mg/100g (Local1), for Fe contents 5.49 (Kayı 91) and 7.19 mg/100g (Local 1), for Mn contents 1.11 (Local 3) and 1.50 mg/100g (Local 1), for Zn contents 3.63 (Yusufhan) and 3.97 mg/100g (Local 3) and for Mo contents 0.30 (Local 1) and 0.38 mg/100g (Local 3). While the greatest K, Ca, Mg, Cu, Fe and Mn contents were observed in Local 1 line, the greatest Zn and Mo contents were observed in Local 3 line. K, Ca, Mg, Fe, Mn and Zn contents were higher in the first year than in the second year and Mo content was higher in the second year than in the first year (Table 2).

Lentil seeds are quite rich in calcium, iron and zinc. They reduce iron deficiency and prevent dieting individuals from anemia (Demirbaş 2005). Lentil seeds also have quite high magnesium contents which reduce blood pressure and facilitate blood stream (Abu Shakra and Tannous 1981; Baysal and Basoglu 1988; Kaya 2010; Ezzad Fariz et al. 2013). Zn content of lentil seeds vary between 3.2 - 6.3 mg/100 g. Lentils also contain small quantities of Cu, Mn, Mo and B (Umeta et al. 2005; Demirbas 2005; Ezzad Fariz et al. 2013). Previous studies also reported similar mineral contents with the present findings (Iqbal et al. 2006., Wang et al. 2009; Kaya 2010; Karakoy et al. 2012; Alghamdi et al. 2014; Wang 2014; Salem et al. 2014).

There were significant differences in thousand grain weights, water intake capacity, bulk density and hydration capacity of the years; thousand grain weights, husk ratios, water intake capacity and swelling capacity of the cultivars and lines. The effects of year x cultivar/line interactions on thousand grain weights were also found to

be significant (Table 3). In combined years, thousand grain weights varied between 32.4 g (Ceren) and 55.1 g (Local 2) with an average value of 50.3 g. The cultivars Pul 11, the lines Local 1 and Local 3 were placed in the same statistical group with the lines Local 2 with the greatest thousand seed weight (55.1 g). As the average of the years, seed coat ratios of the cultivars and lines varied between 8.30% (Pul 11) and 9.23% (Local 4) with an average value of 8.60%. The varieties Ceren, Yusufhan, Kayı 91 and line Local 2 were placed in the same statistical group with the line Local 4 with the greatest husk ratio (9.23%). As the average of the years, water intake capacity of the cultivar varied between 0.032 (Ceren) and 0.064 g seed^{-1} (Yusufhan). With regard to water intake capacity, except for the genotype Ceren, all the other genotypes were placed in the same statistical group. Average swelling capacity of the cultivar varied between 0.023 (Ceren) and 0.055 ml seed^{-1} (Kayı 91) and again except for the cultivar Ceren, all the other cultivars and lines were placed in the same statistical group. Average bulk density of the lines varied between 1.05 (Local 2) and 1.30 g ml^{-1} (Local 1) and except for the line Local 2, all the other cultivars and lines were placed in the same statistical group. As the average of the years, hydration capacity of the cultivars and lines varied between 95.0% (Ankara Yesili) and 118.3% (Local 4) with an average value of 108.6%. Except for the cultivars Ceren and Ankara Yesili, all the other cultivars and lines were placed in the same statistical group. Thousand grain weights and unit volume weight of the first year were higher than in the second year, water intake capacity and hydration capacity values on the other hand were higher in the second year than in the first year (Table 3). Thousand grain weights were previously reported as between 29.8 and 44.2 g by Bicer and Sakar (2007), as between 27.2 and 44.0 g by Bicer and Sakar (2011) as between 31.4 and 53.4 g by Ozer and Kaya (2010) and as between 19.3 and 32.4 g by Rani and Grewal (2014). Thousand seed weight is a cultivar-specific attribute and thus influenced more by genetic factors (Bozdemir 2007; Aghili et al. 2012; Wang 2014; Toklu et al. 2017). In previous studies, Jood et al. (1998) reported hydration capacities of lentil seed as between 0.019 and 0.026 g seed^{-1}, swelling capacities as between 0.018 and 0.025 ml/seed and unit volume weight as between 0.82 - 0.93 g ml^{-1}. Sharif et al. (2014) reported swelling capacity of lentil seeds as between 0.018 - 0.024 ml seed^{-1}, hydration capacities as between 0.018 - 0.022 g seed^{-1}, water absorption capacities between 0.017 - 0.022 g seed^{-1}. Rani and Grewal (2014) reported swelling capacity of the lentil seeds as between 0.030 - 0.050 ml seed^{-1}, water absorption capacities between 0.019 - 0.030 g seed^{-1}, Unit volume weight as between 1.19 - 1.31 g ml^{-1}. Ozer and Kaya (2010) reported hydration capacities of the lentil seeds as between 0.028 - 0.051 g seed^{-1}. Kaya (2010) indicated significant differences in water absorption capacity of lentil genotypes and reported higher values for larger seeds.

Table 2. Mineral contents of lentil cultivars and lines (mg 100g^{-1})

Cultivars /Lines^{+}	K	Ca	Mg	Cu	Fe	Mn	Zn	Mo
Pul 11	881.1 ab	82.2 ab	75.1 ab	0.98 a	6.65	1.40 ab	3.84	0.33
Ceren	838.3 bcd	78.3 bc	71.4 bcd	0.92 a	6.52	1.32 ab	3.75	0.33
Ankara Yesili	812.1 cd	77.2 bc	66.8 cd	0.90 a	6.08	1.25 bc	3.64	0.33
Yusufhan	821.1 cd	78.2 bc	68.9 bcd	0.93 a	5.85	1.32 ab	3.63	0.32
Kayı 91	846.2 bc	80.5 abc	71.6 a-d	0.91 a	5.49	1.33 ab	3.79	0.32
Local 1	904.7 a	84.7 a	78.5 a	1.01 a	7.19	1 50 a	3.83	0.30
Local 2	879.0 ab	82.2 ab	75.3 ab	0.96 a	6.87	1.35 ab	3.86	0.31
Local 3	786.3 d	75.2 c	66.2 d	0.76 b	6.26	1.11 c	3.97	0.38
Local 4	865.3 abc	81.4 ab	73.6 abc	0.94 a	6.63	1.37 ab	3.84	0.32
Mean	848.2	80.0	71.9	0.93	6.39	1.32	3.79	0.32
Years								
2014-2015	895.5 A	83.0 A	77.3 A	0.95	6.97 A	1.39 A	3.94 A	0.32 B
2015-2016	801.0 B	77.0 B	66.6 B	0.90	5.82 B	1.26 B	3.65 B	0.33 A
Year (Y)	**	**	**	ns	**	**	**	ns
Genotype (G)	*	*	*	*	ns	*	ns	ns
Y×G	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	3.68	3.95	2.12	3.9	4.1	2.9	3.25	3.4

K- Potassium; Ca- Calcium; Mg- Magnesium; Cu- Copper; Fe- Iron; Mn- Manganese; Zn- Zinc; Mo- Molybdenum; *Significant at P≤0.05; **Significant at P≤0.01; ns- Non Significant at P > 0.05; $^{+}$The difference between the averages shown with the same letters is not significant at the 5% level.

Biplot analysis revealing significant relationships among several traits of several cultivars and lines has various advantages over correlations yielding relationships only between two traits (Yan and Reid 2008). In biplot analysis of the present study, IPCA (Interaction Principal Component Axis) 1 explained 47.5% and IPCA 2 explained 16.2% (67.3% in total) of variation in investigated traits (Figure 1). As it can be seen in Figure 1, the vectors for starch ratio and amylose ratio extended along the same direction. On the other hand, the traits negatively correlated with these parameters (swelling capacity, water absorption capacity, thousand seed weight,

hydration capacity, ash ratio, protein ratio, Fe and Zn content) had vectors extending along the same direction. While ash content, seed coat ratio, Cu, Mn, K, Mg and Ca content vectors extended along the same direction, Mo content negatively correlated with these parameters. NO and AO value were quite high in Ankara Yesili, Yusufhan, Kayı 91 cultivars and Local 3 line. Also, in Local 3-line, Mo content was high, but the element contents were low. Local 1 line was found to be prominent with its protein ratio, K, Ca, Mg, Cu, Fe and Mn contents. Since the cultivar Kayı 91 was close to the origin, it was not found to be prominent with any of the investigated traits (Figure 1).

Table 3. Thousand grain weights and physico-chemical properties of lentil cultivars and lines

Cultivars /Lines[+]	TGW	SCR	WAC	SC	UVW	HC
Pul 11	53.5 abc	8.30 b	0.063 a	0.046 a	1.11	117.8
Ceren	32.4 d	8.68 ab	0.032 b	0.023 b	1.25	98.5
Ankara Yesili	50.9 c	8.10 b	0.055 a	0.049 a	1.12	95.0
Yusufhan	51.6 bc	8.57 ab	0.064 a	0.043 a	1.08	107.5
Kayı 91	51.5 bc	9.18 a	0.056 a	0.055 a	1.24	107.0
Local 1	54.3 ab	8.45 b	0.058 a	0.050 a	1.30	112.3
Local 2	55.1 a	8.67 ab	0.056 a	0.044 a	1.05	107.5
Local 3	53.5 abc	8.22 b	0.059 a	0.050 a	1.14	112.8
Local 4	51.0 c	9.23 a	0.056 a	0.044 a	1.21	118.3
Ortalama	50.3	8.60	0.056	0.045	1.17	108.6
Years						
2014-2015	51.6 A	8.63	0.053 B	0.048	1.26 A	104.0 B
2015-2016	49.2 B	8.57	0.058 A	0.041	1.08 B	113.2 A
Year (Y)	**	ns	**	ns	**	*
Genotype (G)	**	*	**	*	ns	ns
Y×G	**	ns	ns	ns	ns	ns
CV	4.49	3.79	4.1	4.2	3.5	3.2

TGW- Thousand grain weight ; SCR- seed coat ratio; WAC- water absorption capacity; SC- Swelling capacity; UVW- Unit volume weight; HP- hydration capacity; *Significant at P≤0.05; **Significant at P≤0.01; ns- Non Significant at P > 0.05; [+]The difference between the averages shown with the same letters is not significant at the 5% level.

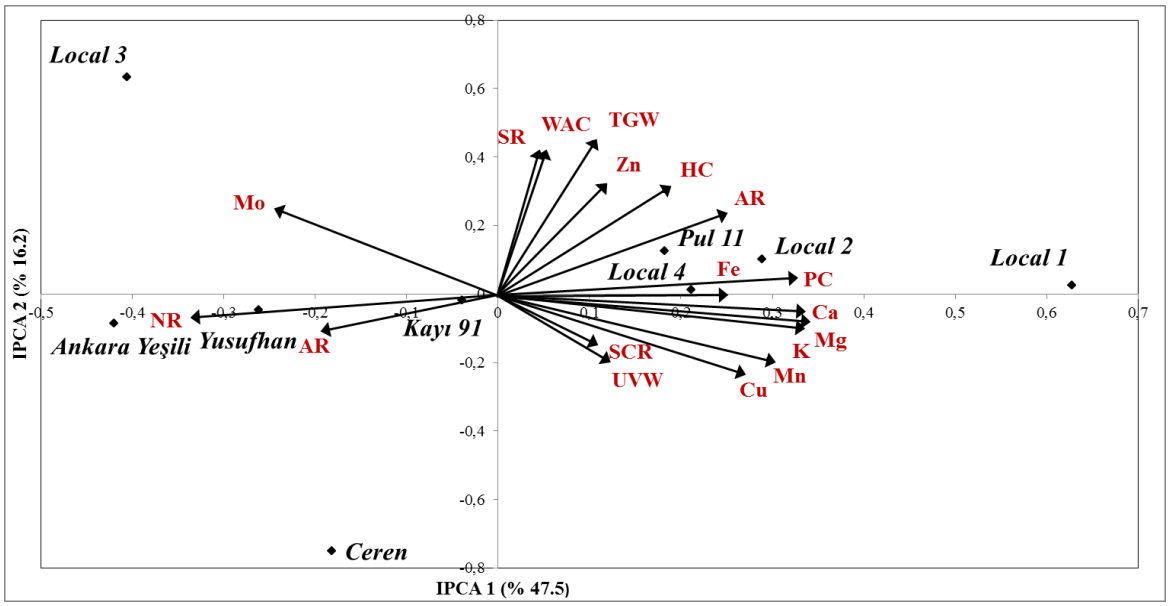

Figure 1. The grouping of the examined features by biplot analysis method and the relation of cultivars and lines with the examined features.

AC- Ash ratio; PC- Protein ratio; SC- Starch ratio; AC- Amylose ratio; K- Potassium; Ca- Calcium; Mg- Magnesium; Cu- Copper; Fe- Iron; Mn- Manganese; Zn- Zinc; Mo- Molybdenum; TGW- Thousand grain weight ; SCR- seed coat ratio; WAC- water absorption capacity; SC- Swelling capacity; UVW- Unit volume weight; HP- hydration capacity

Conclusion

Significant differences were observed in investigated traits of the lentil cultivars and lines. Present parameters are the primary traits used to assess the quality. Genetic factors significantly influenced these quality traits. Such

effects were quite significant in some lentil cultivars and lines and were limited in some others. In present study carried out under Yozgat ecological conditions for two years, the cultivars Ankara Yesili, Yusufhan and Kayı 91 were found to be prominent with their amylose and starch ratios, the line Local 2 was prominent with its protein and ash ratios. Local 1 was identified as the genotype with the greatest mineral composition (except for Mo). The cultivar Kayı 91 was placed close to the origin in biplot graph and had medium level quality parameters. It was concluded based on present findings that quality attributes are greatly influenced by local climate and soil conditions, agricultural practices and analysis methods.

Acknowledgement

This article has been produced from first authors doctoral thesis.

References

Abu-Shakra S, Tannous RI (1981). Nutritional value and quality of lentils. Lentils pp.191-202. Commonwealth Agricultural Bureaux. Webb C and Hawtin G (eds.), Farnhan Royal, Slough SL2 3BN, England.

Aghili P, Imani AA, Shahbazi H, Alaei Y (2012). Study of correlation and relationships between seed yield and yield components in lentil (*Lens culinaris* Medik). Annals of Biological Research, 3: 5042-5045.

Alghamdi SS, Khan AM, Ammar MH, El-Harty EH, Migdadi HM, Abd El-Khalik S M, Al-Shameri AM, Javed MM, Al-Faifi SA (2014). Phenological, nutritional and molecular diversity assessment among 35 introduced lentil (*Lens culinaris* Medik.) genotypes grown in Saudi Arabia. International Journal of Molecular Sciences, 15: 277-295.

Aydoğan A, Karagül V, Gürbüz A (2008). Farklı ekim zamanlarının yeşil ve kırmızı mercimeğin (*Lens culinaris* Medik.) verim ve verim öğelerine etkileri. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 17(1-2):25-33.

AOAC (2005). Official methods of analysis (18th ed.), Association of Official Analytical Chemists, Arlington, VA.

Baysal AS, Basoglu S (1988). Role of chickpeas and lentils in human nutrition. Chickpeas and Lentils Symposium. January 14-15 1988. Side, Antalya, Turkey, Turkish Grain Board Press, pp. 17-23.

Bicer BT, Sakar D (2007). Comparision of Exotic Lentil Lines to Native Cultivars for Agronomic and Morphologic Traits. Ankara University, Faculty of Agricultural Engineering, Journal of Agricultural Science, 13 (3): 279-284.

Bicer BT, Sakar D (2011). Mercimek (*Lens culinaris* Medik.) hatlarının verim ve verim özellikleri yönünden değerlendirilmesi. Harran University Faculty of Agricultural Sciences. 15(3): 21-27.

Bozdemir C (2007). Determination of performance of spring green lentil lines in Ankara ecology. Selcuk University, Graduate School of Natural and Applied Science, MSC Thesis, Konya-Turkey.

Chung HJ, Liu Q, Hoover R, Warkentin TD, Vandenberg B (2008). In vitro starch digestibility, expected glycemic index, and thermal and pasting properties of flours from pea, lentil and chickpea cultivars. Food Chemistry, 111: 316-321.

Coskuner Y, Karababa E (1998). Production potantial and process technology of lentil in Turkey. GIDA. 23(3): 201-209.

Demirbas A (2005). β-Glucan and mineral nutrient contents of cereals grown in Turkey. Food Chem. 90: 773-777.

Ezzad Faris MA, Takruri HR, Issa AY (2013). Role of lentils (*Lens culinaris* L.) in human health and nutrition: a review. Mediterranean Journal of Nutrition and Metabolism, 6 (1): 3-16.

FAO (2014). Statistical Databases, http://faostat.fao.org/site/567/default.aspx#ancor, (Erişim tarihi: 14 May, 2017).

Hoover R, Hughes T, Chung HJ, Liu Q (2010). Composition, molecular structure, properties, and modification of pulse starches: A review. Food Research International, 43(2): 399-413.

Iqbal A, Khalil IA, Ateeq N, Khan MS (2006). Nutritional quality of important food legumes. Food Chemistry, 97: 331-335.

Jood S, Bishnoi S, Sharma A (1998). Chemical analysis and physico-chemical properties of chickpea and lentil cultivars. Nahrung, 42: 71-74.

Kahraman A (2016). Nutritional components and amino acids in lentil varieties. Selcuk Journal of Agriculture and Food Sciences. 30(1): 34-38.

Karakoy T, Erdem H, Baloch FS, Toklu F, Eker S, Kilian B, Ozkan H (2012). Diversity of macro- and micronutrients in the seeds of lentil landraces. The Scientific World Journal, 2012: 1-9. DOI:10.1100/2012/710412.

Karayel R (2012). Determination of some physicochemical components of pea genotypes sown in Samsun and

evaluation of their suitability for breeding. Ondokuz Mayis University, Graduate School of Natural and Applied Science, PhD Thesis, Samsun-Turkey.
Kaya F (2010). Determination of the composition of some lentil varieties grown in our country. Cukurova University, Graduate School of Natural and Applied Science, MSC Thesis, Adana-Turkey.
Kesli Y (2009). Effects of different harvest time and sulphur fertilization on yield, yield components, and aminoacid composition of lentil (*Lens culinaris* Medik.). Ankara University, Graduate School of Natural and Applied Science, PhD Thesis, Ankara-Turkey.
Lipkovich I, Smith EP (2002). Biplot and singular value decomposition macros for excel. Department of Statistics Virginia Tech Blacksburg, VA 24061-0439. http://www.jstatsoft.org/v07/i05/paper (Erişim tarihi: 09.092017)
Ozer MS, Kaya M (2010). Physical, chemical and physicochemical properties of some lentil varieties grown in Turkey. Journal of Food, Agriculture & Environment, 8 (3-4): 610-613.
Padovani RM, Lima DM, Colugnati FAB, Rodriguez-Amaya DLB (2007). Comparison of proximate, mineral and vitamin composition of common Brazilian and US food. J Food Comp Anal. 20: 733–738
Rani V, Grewal RB (2014). Physical and functional properties of six varieties of lentil (*Lens culinaris* Medik.). Asian Journal of Dairy and Food Research, 33(2): 126-130.
Ryan E, Galvin K, O'Connor TP, Maguire AR, O'Brien NM (2007). Phytosterol, squalene, tocopherol content and fatty acid profile of selected seeds, grains, and legumes. Plant Foods Hum. Nutr. 62: 85–91.
Salem AA, Bostany E, Nahla A, Samia Al-Askalany A, Thabet HA (2014). Effect of domestic processing methods of some legumes on phytochemicals content and in vitro bioavailability of some minerals. Journal of American Science, 10(12): 276-288.
Sandhu JS, Lim ST (2008). Digestibility of legume starches as influenced by their physical and structural properties. ELSEVIER, Carbohydrate Polymers, 71: 245-252.
SAS Institute (1998). INC SAS/STAT users' guide release 7.0, Cary, NC, USA.
Shahwar D, Bhat TM, Ansari MYK, Chaudhary S, Aslam R (2017). Health functional compounds of lentil (*Lens culinaris* Medik): a review. Intenational Journal of Food Proreties. 1-15pp. ISSN: 1094-2912, 1532-2386 (Online). DOI: 10.1080/10942912.2017.1287192.
Sharif, HR, Zhong F, Anjum FM, Khan MI, Sharif MK (2014). Effect of soaking and microwave pretreatments on nutritional profile and cooking quality of different lentil cultivars. Pakistan Journal of Food Science. 24(4): 186-194.
Sehirali S (1988). Grain legume crops. Ankara University, Faculty of Agricultural Engineering, Ankara, Turkey 1089 (314), p. 435.
Toklu F, Biçer BT, Karaköy T (2009). Agro-morphological characterization of the Turkish lentil landraces. African Journal of Biotechnology, 8 (17): 4121-4127.
Toklu F, Ozkan H, Karaköy T, Coyne CJ (2017). Evaluation of advanced lentil lines for diversity in seed mineral concentration, grain yield and yield components. Journal of Agriculture Science, 23:213-222.
Trowell H, Burkıtt D, Heaton K (1985). Dietary Fibre, Fibre- Depleted Foods and Disease, Academic Press, London, England, 433p.
TUIK (2015). Agricultural Statistics database. Turkish Statistical Institute, Ankara, www.tuik.gov.tr (Erişim tarihi: 01 May, 2017).
Umeta M, West CE, Fufa H (2005) Content of Zn, Fe, Ca and their absorption inhibitors in foods commonly consumed in Ethiopia. J. Food Comp. Anal. 18: 803-817.
Urbano G, Porres JM, Frias J, Concepeio VV (2007) Nutritional value. Lentil: an Ancient Crop for Modern Times. Yadav SS, McNeil DL and Stevenson PC (eds) Springer, Heidelberg, pp. 47–93.
Wang N, Daun JK (2006). Effects of variety and crude protein content on nutrients and anti-nutrients in lentils (*Lens culinaris*). Food Chemistry, 95: 493–502.
Wang N (2008). Effect of variety and crude protein content on dehulling quality and on the resulting chemical composition of red lentil (*Lens culinaris*). Journal of the Science of Food and Agriculture, 88: 885-890.
Wang N, Hatcher DW, Toews R, Gawalko EJ, (2009). Influence of cooking and dehulling on nutritional composition of several varieties of lentils (Lens culinaris). Food Sci. Technol. 42: 842-848.
Wang N (2014). Quality of western Canadian lentils. Program Manager, Pulse Research. Canadian Grain Commission, 1-14.
Yadav SS, Stevenson PC, Rizvi AH, Manohar M, Gailing S, Matelyan G (2007) Uses and consumption. Lentil: an Ancient Crop for Modern Times. Yadav SS, McNeil DL and Stevenson PC (eds) Springer, Dordrecht, The Netherlands, pp. 33–46.
Yan W, Reid JF (2008). Breeding line selection based on multiple traits. Crop Sci. 48: 417-423.
Zia-ul-Haq M, Iqbal S, Ahmad S, Imran M, Niaz A, Bhanger MI (2007). Nutritional and compositional study of Desi chickpea (*Cicer arietinum* L.) varieties grown in Punjab. Pakistan. Food Chem. 105: 1357-1363.