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Research article

Determination of Chemical and Mineral Compositions of Promising Almond (*Prunus amygdalus* L.) Genotypes from Beyazsu (Mardin) Region

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Abstract. The aim of the present work was to determine the compositions of main chemicals and minerals in kernels of promising almond genotypes grown in Beyazsu (Mardin) region of Turkey. In this context, the crude oil, crude protein, total sugar, ash and moisture contents of the almod gonetypes ranged from 48.93 to 55.96%, 20.81 to 25.99%, 2.91 to 4.06%, 3.12 to 4.69% and 2.28 to 3.70%, respectively. Moreover, potassium content was determined predominant mineral in all genotypes, ranging from 646.27 to 925.13 mg $100g^{-1}$; phosphorus content was the next most abundant mineral, ranging from 562.53 to 701.93 mg $100g^{-1}$; followed by magnesium and calcium contents, ranging from 217.13 to 367.27 mg $100g^{-1}$, 190.97 to 317.13 mg $100g^{-1}$, respectively. According to the results of this study, we can conclude that the kernels of almond genotypes are being potential sources of valuable chemical and mineral contents which might be used for edible and some industrial applications.

Beyazsu (Mardin) Yöresisindeki Üstün Badem (*Prunus amygdalus* Batsch) Genotiplerinin Kimyasal ve Mineral Kompozisyonlarının Belirlenmesi

Anahtar kelimeler:
Badem, kimyasallar, mineraller, Mardin

Özet. Mevcut çalışmanın amacı, Türkiye'nin Beyazsu (Mardin) yöresinde yetişen üstün badem genotiplerinin tohumlarındaki önemli kimyasal ve minerallerin kompozisyonlarını belirlemektir. Araştırmada incelenen badem genotiplerinin ham yağ, ham protein, toplam şeker, kül ve nem içerikleri sırasıyla %48.93 ile 55.96, %20.81 ile 25.99, %2.91 ile 4.06, %3.12 ile 4.69 ve % 2.28 ile 3.70 arasında değişmiştir. Ayrıca, tüm genotiplerde temel mineral olarak belirlenen potasyum içeriği 646.27 ile 925.13 mg $100g^{-1}$, bir sonraki en bol mineral olan fosfor içeriği 562.53 ile 701.93 mg $100g^{-1}$ arasında değişmiştir. Bunları magnezyum ve kalsiyum içerikleri takip ederek sırasıyla 217.13 ile 367.27 mg $100g^{-1}$ ve 190.97 ile 317.13 mg $100g^{-1}$ arasında değişmiştir. Bu çalışmanın sonuçlarına gore, badem genotiplerinin tohumlarının yenilebildikleri ve bazı endüstriyel uygulamalar için kullanılan değerli kimyasal ve minerallerin potansiyel kaynağı olduğu sonucuna varılabilir.

INTRODUCTION

Almond (*Prunus amygdalus* L.) is one of the most important and the largest productions of nuts in the world (Kester and Gradziel 1991; Yildirim *et al*., 2008). Turkey is one of significant countries in the world in terms of almond production. The total annual world almond production is about 2.697.209 tons. USA, Australia, Spain, Iran, Morocco and Iran produce 1.545.500, 160.000, 195.704, 111.936 and 101.026 tons of almonda annually, respectively. Turkey ranks sixth in the world, producing 73.230 tons of almond (FAO 2014).

Almond kernels were much requested products and their destinations are the direct consumption after harvest (Piscopo *et al*., 2010). Moreover, almond fruits are evaluated in the confectionery industry, the production of sweets, cakes and sugar coated almonds. From the pre-agricultural eras to the present day, almonds and other nuts have been significant part of the human diet, providing micronutrients, macronutrients, and various bioactive components (Yildirim *et al*., 2008; Beyhan *et al*., 2011; Şen and Karadeniz 2015; Simsek 2016). In addition, the kernels have been used to prevent important diseases of the heart and autoimmune system, rheumatoid arthritis, and cancer in recent years (Jenkins *et al*., 2002).

The chemical compositions of almond, pistachio, walnut, hazelnut, and chestnut kernels suggest that these materials are very valuable for nutritionally (Saura-Calixto and Cafiellas 1982; Bliss 1999; Küçüköner and Yurt 2003; Pereira-Lorenzo *et al*., 2006; Muradoğlu and Balta 2010; Beyhan *et al*., 2011; Moaydi *et al*., 2011; Yerlikaya *et al*., 2012; Çöpür *et al*., 2013; Şen and Karadeniz 2015; Simsek 2016). The chemical and mineral compositions of almond fruit are of great significance to establish its nutritive value and its quality for the recent concern of consumers over ensuring a healthy life style. In this context, Simsek and Demirkiran (2010) found that the chemical composition of almond genotypes in Diyarbakir region ranged from 43.50 to 54.81% crude oil, 21.18 to 32.90% crude protein, 3.08 to 4.43% moisture and 2.54 to 4.42% ash. Moreover, Piscopo *et al.* (2010) reported that the mineral contents of almond cultivars are follow: potassium, 525.46-793.86 mg $100g^{-1}$, magnesium, 154.15-275.87 mg $100g^{-1}$, and calcium, 89.97-176.50 mg $100g^{-1}$.

Many studies have been carried out especially dealing with the chemical and mineral compositions of almond grown in Turkey (Simsek and Demirkiran 2010; Ozcan *et al*., 2011; Yildirim *et al*., 2008; Beyhan *et al*., 2011; Şen and Karadeniz 2015; Simsek 2016). Beyazsu region, loacted between Nusaybin and Midyat districts of Mardin in Turkey, has a distinctive microclimatic environment derived from the Beyazsu waterfall. Around the waterfall area, climatic conditions are similar to those seen in the Mediterranean region. The climatic conditions of this region aren't similar to those seen in Mardin province in the Southeast Anatolia region. In this microclimate, there are also fruit trees such as pomegranate, figs, walnut, almond and mulberry and forest trees such as pine, poplar and sycamore flourish. To our knowledge, no studies on chemical and mineral compositions of almond genotypes have been reported in Bayaszsu region of Southeast Turkey up to now. Therefore, the present study is very significant.

The objectives of this study were to determine the levels of significant chemical and mineral compositions in different genotypes of almond kernels in this region. These results obtained might contribute to breeding studies, commercial production, nutritional and technical applications, and healthy diets in future.

MATERIALS AND METHODS

This study was carried out in the Beyazsu (Mardin) region of Turkey. This region is situated between $37^{0}16'3.23''$ N - $41^{0}18'4.60''$ E coordinates in North part and $37^{0}5'52.84''$ N - $14^{0}42'$ $5''$ E coordinates in South part, with 350 to 1000 m attitudes (GEF 2017). In present study, the nine of hundred and two almond genotypes were selected from this region during years 2012-2013. In this study, the determination of chemical and mineral compositions of kernels of promising almond genotypes were analyzed in August 2013.

After harvesting for determination of chemical and mineral compositions, the almond kernels were dried and stored in their shells at room temperature prior to analysis. The kernel samples of almond genotypes were grinded and moisture was determined before the chemical analysis. Moisture content was analyzed and calculated according to the methods given by the Turkish Standard Institute (AOAC 1990). For crude oil analyses, the samples were homogenized and subjected to extraction for 6 h with petroleum ether (boiling range 30-60 ^{0}C) in a Soxhlet apparatus. The extracted total crude oil was dried over anhydrous sodium sulphate and the solvent was removed under reduced pressure in a rotary film evaporator. Crude oil percentages of the kernel samples of almond genotypes were determined by weight difference

(Kaplankıran 1984). Ash was determined in crucible to a muffle furnace at 900 ^{0}C for 8 h (AOAC 1990). The nitrogen content was estimated by the Kjeldahl method and was converted to crude protein content by using the conversion factor 6.25 (AOAC 1990). Total sugar content was determined by the Anthrone method (Kaplankıran 1984). The magnesium, calcium, iron, copper, zinc, and manganese contents of the samples were determined via Perkin Elmer 703 atomic absorption spectrophotometry, and the sodium and potassium contents were measured via flame emission spectrometry (Saura-Calixto and Cafiellas 1982). Phosphorus was measured by colorimetric method (Saura-Calixto and Cafiellas 1982).

Statistical analyses of chemical and mineral compositions of the samples of promising almond genotypes were performed in triplicate. All data were subjected to analysis of variance with the aid of SPSS Inc (PASW Statistics 18). Differences between means were considered to be significant at 0.05 level.

RESULTS AND DISCUSSION

Crude oil is the principal kernel constituent of almond genotypes and cultivars. In this context, the samples showed only a relatively small variation of crude oil content in the range from 48.93 (MBSU4) to 55.96% (MBSU72) on dry weight basis (Table 1). The oil content is a relatively stable feature independent on the different genotypes. In various almond varieties that differed in genotypes, the oil contents were previously reported to range from 43.50 to 54.81% (Simsek and Demirkiran 2010), 52.08 to 57.49% (Agar *et al*., 1997), 48.80% to 55.70% (Ozcan *et al*., 2011) and 52.00 to 56.00% (Barbera *et al*., 1994). In the present study, the oil contents were similar to those previously recorded. The almond kernel is high in crude oil and energy, and kernels do not constitute a bulky diet.

The crude protein contents of samples ranged from 20.81 (MBSU72) to 25.99% (MBSU4) (Table 1). In various works, the crude protein contents varied from 22.50 to 25.80% (Barbera *et al*., 1994) and 18.00 to 25.00% (Soler *et al*., 1989). In the present study, the crude protein contents of samples agreed well with earlier results (Barbera *et al*., 1994; Soler *et al*., 1989). Because the crude protein content of the samples is high, almond kernels may serve as dietary supplements for unhealthy people who require crude protein and suffer from hypertension.

The total sugar content of samples ranged from 2.91 (MBSU4) to 4.06% (MBSU72 (Table 1). The sugars are carbohydrates typically found in both almond kernels and other plant tissues, and can be digested, absorbed, and metabolised by humans to provide energy. In previous works, the total sugar content ranged from 3.10 to 5.30 (Romojaro *et al*., 1988), and 2.10 to 7.4% (Yada *et al*., 2011). In the present study, the total sugar contents of the samples agreed well with earlier results (Romojaro *et al*., 1988; Yada *et al*., 2011).

The moisture contents of samples ranged from 2.28 (MBSU28) to 3.70% (MBSU88) in the samples (Table 1). In general, the availability of moisture encourages the growth of microorganisms and hence microbial spoilage of food is not advisable to store almond kernels fresh. In various studies, the moisture contents changed from 3.08 to 4.43% (Simsek and Demirkiran 2010) and 9.50 to 10.50% (Mbah *et al*., 2013). In the present study, the moisture contents of samples agreed with earlier data (Simsek and Demirkiran 2010; Mbah *et al*., 2013). The moisture content should be reduced by drying to increase the safe storage time.

The ash contents of samples ranged from 3.12 (MBSU64) to 4.69% (MBSU97) in the samples (Table 1). The ash content ranged from 2.54 to 4.42% (Simsek and Demirkiran 2010), 2.74 to 3.05% (Ozcan *et al*., 2011), 2.30 to 3.70% (Ruggeri *et al*., 1998), and 2.60 to 4.60% (Ahrens *et al*., 2005). The ash contents of the samples agreed with earlier data (Simsek and Demirkiran 2010; Ruggeri *et al*., 1998; Ahrens *et al*., 2005). Chemical levels of almond genotypes and cultivars can change according to the genetic differences, ecological, maintenance and cultural conditions.

Table 1. Chemical composition of promising almond genotypes (%).
Çizelge 1. Seçilmiş badem genotiplerin kimyasal kompozisyonu (%).

Genotypes	Moisture	Crude oil	Crude protein	Ash	Total sugar
MBSU4	3.47±0.27	48.93±0.10	25.99±0.13	4.17±0.11	2.91±0.07
MBSU13	3.26±0.08	55.79±0.18	22.20±0.48	4.59±0.17	3.86±0.09
MBSU28	2.28±0.23	49.42±0.37	25.34±0.57	4.56±0.10	3.70±0.41
MBSU49	3.23±0.19	51.64±0.96	21.44±0.67	4.22±0.11	3.07±0.17
MBSU64	3.33±0.14	52.06±0.67	21.59±0.41	3.12±0.12	3.30±0.11
MBSU72	3.10±0.12	55.96±0.03	20.81±0.15	3.25±0.14	4.06±0.18
MBSU88	3.70±0.40	52.07±0.56	22.87±0.42	3.85±0.14	3.18±0.15
MBSU91	2.75±0.11	51.72±0.33	24.42±0.42	3.50±0.13	3.80±0.17
MBSU97	3.22±0.21	48.97±0.27	23.15±0.44	4.69±0.10	3.62±0.15
Mean	3.15	51.84	23.09	4	3.50
Min.	2.05	48.71	20.65	3.01	2.85
Max.	398	5599	2614	4.79	4.23
SD	0.44*	2.56*	1.78*	0.58*	0.41*

*statistically significant (at 0.05 level).

The amount of the minerals studied in the promising almond genotypes are shown in Table 2, referred to non-dried matter. Among the all studied genotypes MBSU72 almond kernel contained the highest potassium (925.13 mg $100g^{-1}$). The phosphorus, magnesium, and calcium contents of kernel samples of almond genotypes were found high amounts than those of other minerals. Ca, Mg and P contents of the kernel samples ranged from 190.97 (MBSU64) to 317.13 mg $100g^{-1}$ (MBSU4), 217.13 (MBSU64) to 367.27 mg $100g^{-1}$ (MBSU13) and 562.53 (MBSU4) to 701.93 mg $100g^{-1}$ (MBSU91), respectively. The data obtained from these minerals were found high amounts than those of other elements. However, all of the sodium, copper, iron, zinc, and manganese were only present at trace amounts. Na, Fe, Zn, Mn and Cu amounts ranged from 8.66 (MBSU49) to 14.30 mg $100g^{-1}$ (MBSU4), 5.39 (MBSU4) to 10.28 mg $100g^{-1}$ (MBSU88), 5.43 (MBSU64) to 9.33 mg $100g^{-1}$ (MBSU88), 2.20 (MBSU97) to 4.55 mg $100g^{-1}$ (MBSU49), and 1.66 (MBSU91) to 3.73 mg $100g^{-1}$ (MBSU97), respectively. These results are in most agreement with the mineral contents for kernels of several almond genotypes and cultivars described in literature (Ozcan *et al.*, 2011; Saura-Calixto and Cafiellas 1982). Saura-Calixto and Cafiellas (1982) determined that the mineral composition of seven almond varieties in Spain ranged from 649.00 to 824.00 mg $100g^{-1}$ K, 462.00 to 595.00 mg $100g^{-1}$ P, 239.00 to 280.00 mg $100g^{-1}$ Mg, 218.00 to 299.00 mg $100g^{-1}$ Ca, 4.80 to 12.50 mg $100g^{-1}$ Na, 3.10 to 4.40 mg $100g^{-1}$ Fe, 3.00-4.00 mg $100g^{-1}$ Fe and 0.90 to 1.30 mg $100g^{-1}$ Cu. The average kernel contents of five almond cultivars collected in Antalya and Mugla provinces in Turkey ranged from 1315.00 to 1510.00 mg $100g^{-1}$ K, 793.00 to 938.00 mg $100g^{-1}$ P, 298.00 to 404.00 mg $100g^{-1}$ Mg, 183.00 to 294.00 mg $100g^{-1}$ Ca, 29.00 to 38.00 mg $100g^{-1}$ Na, 20.00 to 27.00 mg $100g^{-1}$ Fe, 4.00 to 6.00 mg $100g^{-1}$ Zn and 1.00 mg $100g^{-1}$ Cu for all the cultivars (Ozcan *et al.*, 2011). Moreover, Barbera *et al.* (1994) reported that kernel contents of two almond varieties changed from 1546.00 to 1685.00 mg $100g^{-1}$ for K, 253.00 to 259.00 mg $100g^{-1}$ for P, 640.00 to 678.00 mg $100g^{-1}$ for Ca, 447.00 to 494.00 mg $100g^{-1}$ for Mg, 24.30 to 25.80 v for Cu. In addition, Saura-Calixto and Cafiellas (1982) observed that average kernel contents of almond cultivars grown in Spain consisted of 766.00 mg $100g^{-1}$ K, 364.00 mg $100g^{-1}$ P, 227.00 mg $100g^{-1}$ Mg and 185.00 mg $100g^{-1}$ Ca. The mineral contents of almond kernels are affected by many environmental factors and agronomic practices including geographic location, soil composition, water source, irrigation regime, fertiliser components, and other aids to agronomic production. In addition, the mineral content can also be influenced by plant genotypes and cultivars.

Table 2. Mineral compositions of promising almond genotypes (mg 100 g^{-1}).
Çizelge 2. Seçilmiş badem genotiplerin mineral kompozisyonları (mg 100 g^{-1}).

Genotypes	K	P	Mg	Ca	Na	Fe	Zn	Mn	Cu
MBSU4	814.03 ±6.99	562.53 ±45.51	331.87 ±1.86	317.13 ±9.00	14.3 ±0.56	5.39 ±0.52	4.47 ±0.49	2.47 ±0.49	2.56 ±0.50
MBSU13	864.37 ±10.80	650.43 ±14.5	367.27 ±11.01	314.17 ±12.55	12.28 ±0.23	6.71 ±0.72	6.40 ±0.40	4.27 ±0.38	3.17 ±0.21
MBSU28	878.23 ±19.82	608.6 ±7.74	363.23 ±30.28	274.73 ±17.26	10.58 ±0.34	5.94 ±0.38	4.37 ±0.51	2.50 ±0.45	2.60 ±0.51
MBSU49	864.1 ±26.11	661.1 ±10.28	334.07 ±5.68	288.27 ±2.41	8.66 ±0.30	9.53 ±0.49	8.54 ±0.49	4.55 ±0.50	2.07 ±0.11
MBSU64	863.23 ±24.30	591.97 ±9.51	217.13 ±1.86	190.97 ±9.62	9.51 ±0.31	6.55 ±0.50	5.43 ±0.15	3.56 ±0.51	2.30 ±0.50
MBSU72	925.13 ±17.35	606.11 ±8.01	320.6 ±26.27	279.2 ±6.61	11.25 ±0.17	8.45 ±0.47	7.67 ±0.56	2.47 ±0.45	3.53 ±0.48
MBSU88	745.9 ±20.15	582.43 ±16.93	332.97 ±9.12	288.93 ±2.57	12.37 ±0.56	10.28 ±0.46	9.33 ±0.54	4.40 ±0.51	3.14 ±0.19
MBSU91	847.77 ±23.87	701.93 ±54.03	348.77 ±37.91	251.43 ±9.62	13.36 ±0.56	9.45 ±0.45	8.37 ±0.44	3.60 ±0.52	1.66 ±0.32
MBSU97	646.27 ±40.75	579.83 ±29.33	319.17 ±23.23	292.03 ±42.63	10.55 ±0.50	7.52 ±0.42	6.33 ±0.55	2.20 ±0.35	3.73 ±0.25
Mean	827.67	616.1	326..12	277..43	11.43	7.76	6.77	3.33	2.75
Min.	613.8	510	215	180	8.32	5	4	2	1.30
Max.	938	761	395	339.1	14.7	10.81	9.96	4.98	3.99
SD	82.76*	49.31*	45.87*	39.15*	1.78*	1.73*	1.78*	0.98*	0.73*

*statistically significant (at 0.05 level).

CONCLUSION

The results of present study show that selected genotypes grown in Beyazsu (Mardin) region have high levels of very valuable components. The studied genotypes showed variations in the ash, crude oil, crude protein, total sugar and moisture. In addition, these genotypes showed good mineral contents. However, very few studies on minerals have thoroughly assessed different almond genotypes and cultivars in Turkey up to now. Therefore, according to the data obtained in this study, we can conclude that the almond genotypes are a rich source of significant nutrients, considered as raw materials in the food industry, very beneficial to human health and provides a knowledge base for almond breeders who formulate breeding programs.

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