Total Phenolics, Antioxidant Capacities and Pomological Characteristics of 12 Apricot Cultivars Grown in Turkey

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Abstract

In this study, pomological analyses and antioxidant capacity and total phenolic compound content assessments of fruits sampled from 12 apricot cultivars commonly cultivated in Turkey. Significant differences between the cultivars were determined in terms of evaluated traits. Antixodant capacities varied between 0.62 and 1.18 µmol TE/g FW, and total phenolic contents were found between 351.83 and 1208.33 µg GAE/g FW among the cultivars. The results of the study were concluded to be beneficial for apricot breeders who are willing to conduct breeding studies to improve related traits by the help of the related cultivars, and also for apricot fruit consumers in selecting higher phytochemical content cultivars.

Keywords: characterization, cultivar, fruit quality, phytochemical, *Prunus armeniaca* L.

Introduction

Apricot (*Prunus armeniaca* L.) is classified under Prunus genus of Rosaceae family, and is native to wide geographical area from Middle Asia to West China including Afghanistan, Pakistan, Tajikistan, Kyrgyzstan, Uzbekistan, and West part of Republic of China (Bailey & Hough, 1979). Today, the fruit is spread and produced worldwide and is one of the most commercially valuable stone fruit species with its more than 3.5 million tons of annual production (FAO, 2019). The fruit is appreciated thanks to its attractiveness, fine taste caused by suitable ratio of sugars and organic acids together with a rich aroma (Gurrieri et al., 2001).

Apricots are mainly consumed as fresh and dried fruit, but also processed for its juice or puree (Radi et al., 1997; Schmitzer et al., 2011).

Even though Turkey is not located in the genetic origin of apricot, the country hosts a large germplasm exhibiting a high variation because of different reasons including the geographical location, suitable ecological conditions, and the propagation methods (Asma & Ozturk, 2005; Asma et al., 2017). Indeed, apricots are grown in almost all provinces of Turkey, and the country produced more than 20% of world total fresh apricot production and more than 60% of world dried apricot production in 2016 (FAO, 2019; INC 2018). Especially Malatya Province of Turkey played a significant role in this production by producing more than half of fresh apricot and more than 80% of dried apricot production of the country in 2016 (TUİK, 2018; Anonymous, 2018). In general, apricots for fresh consumption are grown in southern and western provinces, located in Aegean, Mediterranean, and Marmara regions of Turkey, while the dried apricots mostly grown in the inner provinces (Ercisli, 2009). Despite the high production quantities, fresh apricot exports of Turkey have not reached the desired levels yet, since the country has important potential for fresh apricot exports market due to ecological advantages compared to France, Greece, and Spain. The Mut valley is the earliest apricot producing areas in the Europe. Thus, the first fresh apricots are sold for a high price (Ercisli, 2009). Cultivars grown in Turkey are mainly from Irano-Caucasian eco-geographical group, showed a wide variation based on fruit quality characteristics, harvest season, and yield per tree, and European eco-geographical group which is the most recent and the least variable (Badenes et al., 1998; Asma & Ozturk, 2005).

Market value of fruits is a mean human acceptance determined by especially visual characteristics, firmness, and taste which are important for the competition in the market especially in the presence of various cultivars, other fruits and foods (Abbott, 1999; Ruiz & Egea, 2008). However, the increase in human life threatening health problems in the last century, lead the search for solutions against these problems. Phytochemicals are plant compounds found naturally in plant foods, fruits, vegetables etc., and known to reduce the risk of chronic diseases due to their antioxidative effects (Liu, 2003). Based upon these effects, demands for phytochemicals and antioxidant capacity rich foods have significantly increased and these contents have been accepted as important fruit quality parameters (Gökçen et al., 2017).

Apricots are known as human health friendly fruits thanks to its high antioxidant capacity, anti-inflammatory and immune-stimulating functions which are attributed to the content of many different phenolic compounds (Madrau et al., 2009). Fruit antioxidant capacity and total phenolics content in stone fruit species vary due to many factors, but geographic region of cultivation (Dragovic-Uzelac et al., 2007), and especially known to highly vary between genotypes (Drogoudi et al., 2008, Hegedũs et al., 2010),.

Breeding of new cultivars is close correlated with variability of genetic resources. Therefore, characterization of different genetic resources plays a key role in plant breeding. There are some previous studies investigated fruit quality attributes, antioxidants and total phenolic contents of apricot cultivars. Drogoudi et al. (2008) investigated fruit samples of 29 American and Greek originated apricot cultivars and hybrids for their pomological attributes, as well as antioxidant capacity, and total phenols, total carotenoids, K, Ca and Mg contents. Hegedũs et al. (2010) compared antioxidant properties, total phenolic compounds and vitamin C contents of 27 apricot cultivars from various origins. Caliskan et al. (2012) studied pomological properties, antioxidant capacity, total phenolic compounds, and specific and total sugar contents of 12 apricot cultivars from different origins. However, fruit quality and phytochemical attributes of drying apricot cultivars for had not been evaluated in detail. In this study, 5 Turkish drying apricot cultivars were compared with 7 apricot cultivars for fresh consumption originated from Turkey (5), Afghanistan (1), and USA (1) for their pomological attributes, as well as antioxidant capacity and total phenolic compounds contents. The influence of cultivars on fruit quality and phytochemical parameters were investigated by comparing these characteristics for each cultivar. This information will be useful for breeding studies to improve fruit quality and phytochemical contents in apricot cultivars.

Materials and Methods

Plant materials and experimental area

Seven drying and five fresh consumption apricot cultivars originated from different parts of Turkey, Afghanistan and USA were included in this study (Table 1). Three trees with nine years old from each cultivar grown in Apricot Research Institute Battalgazi Campus in Malatya Province of Turkey (altitude: 730 m) were used for the investigations

Table 1. Apricot cultivars subjected to assessments

Cultivars	Abbreviation	Purpose	Origin	Harvest Date
Hacıhaliloğlu	HH	Drying	Turkey-Malatya	25 June
Kabaaşı	KA	Drying	Turkey-Malatya	22 June
Çataloğlu	ÇT	Drying	Turkey-Malatya	24 June
Soğancı	SO	Drying-Fresh	Turkey-Malatya	27 June
Hasanbey	HA	Drying-Fresh	Turkey-Malatya	14 June
Şekerpare	ŞE	Drying-Fresh	Turkey-Iğdır	21 June
Aprikoz	AP	Fresh	Turkey-Iğdır	23 June
Ağerik	AĞ	Fresh	Turkey-Iğdır	12 June
Tokaloğlu	TO	Fresh	Turkey-Erzincan	15 June
Çağataybey	ÇA	Fresh	Turkey-Mersin	13 June
Stark Early Orange	ST	Fresh	USA	14 June
Roxana	RO	Fresh	Afghanistan	11 June

Cultivation practices including irrigation, fertilization and weed management were done as standard. The study was carried out in 2016 and minimum and maximum temperature and rainfall records were presented in Table 2 (MGM, 2019). Soil was clay textured with 7.5 pH and 40% lime content.

Table 2. Meteorological records of experimental area in 2016 (MGM, 2019)

Months	Minimum Average Temperature (°C)	Maximum Average Temperature (°C)	Rainfall (mm)
February	-0.7	11.2	42.7
March	0.9	14.8	24.3
April	5.5	23.3	11.7
May	9.0	25.1	33.9
June	14.6	31.6	13.3

Fruit samples were collected at physiological maturity described by Anonymous (2014) from each tree and analyzed for pomological fruit quality attributes, trolox equivalent antioxidant capacity (TEAC) and total phenolic compounds (TPC) content.

Pomological evaluations

In terms of pomological evaluations; physical parameters of fruit sizes, fruit weight characters, flesh firmness, fruit skin color indices, and chemical parameters of total soluble solids and titratable acidity were measured.

Fruit sizes of fruit length (FL), fruit lateral width (FLW), fruit ventral width (FVW) were measured as described in Anonymous (2007) in millimeters (mm) by hand digital calipers. Fruit weight parameters of fruit weight (FW), stone weight (SW), flesh/stone ratio (F/S) were measured by precision scales (0.01) in grams (g). Flesh firmness (FF) was measured using a penetrometer (Akyol, GY-3) and expressed in kg/cm^2. Fruit skin color indices (L*, a*, b*) were detected by color meter (Konica Minolta, CR-400) according to CIELAB objective color indices (McGuire, 1992). Here; L*, represented lightness from black (0) to white (100), a* indicated the color of redness from green (0) to red (100) and b*, stated yellowness from blue (0) to yellow (100).

Total soluble solids (TSS) contents were detected by hand digital refractometer (ATAGO Pal-1). Titratable acidity (TA) was measured according to Haffner & Vestrheim (1997).

Analysis of total phenolic compounds content

TPC analyzes were performed on fruit extracts according to the method described by Slinkard & Singleton (1977). Accordingly, fruit extracts (0.5 g from each sample) were mixed with mixture of water and phenol reagent of Folin-Ciocalteu in the ratio of 1:12 (v/v), following that incubated at room temperature for 8 minutes, and then added 10 ml of 15% (w/v) sodium carbonate. Obtained mixtures kept in dark at room temperature for 2 hours, and measured for their absorbance levels were at 760 nm using spectrophotometer (Shimadzu UV-1208, Japan). Gallic acid was used as a standard. Results were calculated according to gallic acid standard and expressed as µg of gallic acid equivalents (GAE) / g fresh fruit weight (µg GAE/g FW).

Analysis of antioxidant capacity

TEAC value of each sample was detected according to the method described by Rice-Evans et al. (1996) and modified by Özgen et al. (2006). According to this method, 7 mM ABTS reagent solutions were prepared and diluted with sodium acetate ($C_2H_3NaO_2$) until 0.700 ±0.01 spectrophotometrical absorbance level at 734 nm. Following this, 2.97 ml buffered solution was mixed with 30 µl fruit extract and kept in dark at room temperature for 10 minutes, and measured for their absorbance levels were at 734 nm using spectrophotometer. Obtained results were calculated according to TEAC standard calibration curve and expressed as µmol of trolox equivalent/g fresh fruit weight (µmol TE/g FW).

Statistics

Statistical analyses were performed using SPSS 23.0 for Windows software. Results were evaluated according to Duncan's test ($P \leq 0.05$). Correlations between traits were determined according to Pearson's correlation test. Besides, principal component analysis was performed to determine the relationships among traits and cultivars.

Results and Discussion

Fruit samples of 12 apricot cultivars used for dry and fresh consumption purposes and originated from different parts of Turkey, Afghanistan, and USA were evaluated for their pomological traits, antioxidant capacity, and total phenolic compounds contents. Results of pomological evaluations were presented in Table 3, and results of phytochemical traits were shown in Table 4.

Results of pomological evaluations

Fruit sizes (length, lateral width and ventral width), fruit and stone weight, flesh/stone ratio, skin color indices (*L**, a*, b*), total soluble solid contents, and titratable acidity of apricot cultivars included in the study were examined as part of pomological evaluations. Significant differences were found between cultivars in all evaluated traits (Table 3).

Roxana resulted with highest values for all fruit sizes (52.25 mm, 49.68 mm, and 47.53 mm for FL, FLW, and FVW, respectively). Lowest FL value was found in Şekerpare (35.56 mm), lowest FLW values were found in Çağataybey (34.81 mm), Şekerpare (35.34 mm), and Çataloğlu (36.17 mm), and lowest FVW values were found in Çağataybey (31.29 mm) and Şekerpare (31.73 mm).

Highest FW value was found in Roxana (68.09 g), whereas Stark Early Orange gave highest SW (3.92 g). Çağataybey (25.12 g) and Şekerpare (25.65 g) had the lowest FW, whereas Çağataybey (1.83 g) and Aprikoz (1.89 g) had the lowest SW and were followed by Şekerpare (1.97 g). Aprikoz and Roxana were the leading cultivars for F/S with the values of 19.37 and 19.01, respectively. Şekerpare was found with lowest F/S (12.02) and followed by Çağataybey (12.73).

FF value was highest in Roxana cultivar (9.21 kg/cm^2), and followed by Kabaaşı (8.35 kg/cm^2) and Ağerik (8.04 kg/cm^2). Lowest FF value was found in Şekerpare (2.58 kg/cm^2), and this was followed by Stark Early Orange (3.52 kg/cm^2) and Hasanbey (4.33 kg/cm^2).

In terms of color parameters, highest values were found in Aprikoz (70.71) for L*, in Ağerik (44.72) for a*, and in Aprikoz, Hacıhaliloğlu, Şekerpare, Çataloğlu, and Soğancı (43.63, 43.51, 42.27, 39.96, and 39.41, respectively) for b*. On the other hand, lowest *L**, a*, and b* values were detected in Çağataybey, Soğancı, and Roxana cultivars (27.60, 7.11, and 8.61, respectively).

Table 3. Pomological analysis results of apricot cultivars subjected to assessments

Cultivars	FL (mm)	FLW (mm)	FVW (mm)	FW (g)	SW (g)	F/S	FF	*L**	a*	b*	TSS (%)	TA (%)
HH	40.74 e	40.01 e	36.29 ef	35.74 fg	2.40 ef	13.93 de	7.26 bc	62.89 bc	13.35 d	43.51 a	25.08 a	0.82 f
KA	43.04 d	40.62 de	37.02 e	41.82 de	2.77 d	14.08 de	8.35 ab	57.90 c	22.26 c	35.36 b	24.06 a	0.78 f
ÇT	38.93 ef	36.17 f	34.63 f	31.63 g	2.20 fg	13.42 de	6.12 cd	58.14 c	24.18 c	39.96 a	22.43 bc	0.82 f
SO	38.88 ef	42.71 cd	39.72 c	40.18 def	2.67 d	14.24 cd	5.17 de	63.75 b	7.11 e	39.41 a	25.15 a	0.99 e
HA	49.86 b	42.85 cd	39.02 cd	57.07 b	3.43 b	15.74 b	4.33 def	36.32 ef	34.23 b	11.22 de	23.66 ab	0.61 g
ŞE	35.56 g	35.34 f	31.73 g	25.65 h	1.97 gh	12.02 f	2.58 f	64.71 b	14.07 d	42.27 a	21.76 c	0.79 f
AP	47.16 c	39.53 e	37.69 de	38.61 ef	1.89 h	19.37 a	5.13 de	70.71 a	12.72 d	43.63 a	16.87 e	0.55 g
AĞ	45.03 cd	42.48 cd	39.80 c	43.41 d	2.64 de	15.47 bc	8.04 ab	43.38 d	44.72 a	19.01 c	17.15 e	1.65 c
TO	43.00 d	45.35 b	42.39 b	48.39 c	3.10 c	14.59 bcd	5.44 cde	40.72 de	39.13 b	13.08 d	15.73 e	2.10 a
ÇA	37.24 fg	34.81 f	31.29 g	25.12 h	1.83 h	12.73 ef	4.67 de	27.60 g	24.44 c	9.14 de	15.62 e	1.21 d
ST	46.64 c	43.56 bc	36.32 ef	56.05 b	3.92 a	13.37 de	3.52 ef	39.00 de	34.72 b	9.40 de	19.24 d	1.57 c
RO	52.25 a	49.68 a	47.53 a	68.09 a	3.51 b	19.01 a	9.21 a	31.41 fg	25.84 c	8.61 e	16.34 e	1.82 b

Differences between values signed with different letters are significant at $P \leq 0.05$

Soğancı, Hacıhaliloğlu, and Kabaaşı were the leading cultivars for TSS contents (25.15 %, 25.08 %, and 24.06 %, respectively) which were followed by Hasanbey (23.66 %). Lowest TSS contents were found in Ağerik, Aprikoz, and Tokaloğlu cultivars (17.15 %, 16.87 %, and 15.73 %, respectively). Highest TA was found in Tokaloğlu (2.10 %), whereas lowest TA was found in Hasanbey and Tokaloğlu (0.61 % and 0.55 %, respectively).

The data obtained from pomological analyzes were in harmony with the values reported by Asma (2011), Bircan et al. (2010) and Yılmaz (2008). The firmness and acidity values obtained in this current study were generally found different from the values obtained in the previous studies and these differences were probably due to the fact that the fruits were harvested during the different physiological maturity periods.

Results of phytochemical evaluations

Total phenolic compounds contents and antioxidant capacities of fruit samples collected from the apricot cultivars included in the study were examined as part of phytochemical evaluations. Significant variations were obtained among the cultivars in terms of their phytochemical profiles evaluated (Table 4).

Table 4. Phytochemical analysis results of apricot cultivars subjected to assessments

Cultivars	**TEAC (µmol TE/g FW)**	**TPC (µg GAE/g FW)**
HH	0.81 g	652.24 bcd
KA	0.62 j	555.89 cd
ÇT	0.84 f	621.34 bcd
SO	0.72 h	511.59 cd
HA	0.96 d	706.30 bc
ŞE	1.03 c	874.19 b
AP	0.67 i	351.83 d
AĞ	1.07 b	907.93 b
TO	0.93 e	551.02 cd
ÇA	0.92 e	400.61 cd
ST	1.18 a	1208.33 a
RO	1.08 b	646.75 bcd

Differences between values signed with different letters are significant at $P \leq 0.05$

The highest antioxidant capacity was found in Stark Early Orange (1.18 µmol TE/g FW) which was followed by Roxana and Ağerik (1.08 and 1.07 µmol TE/g FW, respectively) cultivars. The lowest antioxidant capacity was found in Kabaaşı cultivar (0.62 µmol TE/g FW). Similarly, the highest total phenolic content was found in Stark Early Orange (1208.33 µg GAE/g FW), and this was followed by Ağerik and Şekerpare (907.93 and 874.19 µg GAE/g FW). The lowest total phenolic content was found in Aprikoz (351.83 µg GAE/g FW). Caliskan et al. (2012)

reported higher total phenolic compounds contents for Roxana and Çağataybey cultivars when compared with the results of the current study. The differences could be caused by environmental conditions, and also maturity levels of the fruit samples were collected.

Correlations

Correlation analysis performed to examine the relationships between the traits, and results were presented in Table 5. Fruit size parameters were found positively correlated with each other and also with SW, F/S, FF, a* and b* values, TSS and TA. FL was positively correlated with TEAC and TPC. Fruit weight parameters were found positively correlated with color indices and TA beside of the fruit size parameters. FW was correlated with TEAC, while SW with TPC. F/S was positively correlated with FF, but negatively correlated with TSS. Color indices were found correlated with TSS and TA, but the way of the correlation was varied between the parameters. TEAC and TPC were found positively correlated with each other as expected. Most of the correlation results presented in this current study are different than the results reported by Caliskan et al. (2012) probably caused by different cultivars and environmental conditions.

Table 5. Correlation coefficients between pomological and phytochemical traits in assessed apricot cultivars

Variable	FLW	FVW	FW	SW	F/S	FF	*L**	a*	b*	TSS	TA	TEAC	TPC
FL	0.81**	0.78**	0.83**	0.62**	0.60**	0.26**	-0.21**	0.26**	-0.31**	-0.22**	0.34*	0.50**	0.46**
FLW	1	0.92**	0.86**	0.70**	0.49**	0.28**	-0.16*	0.21**	-0.26**	-0.14*	0.58**	0.23	0.12
FVW		1	0.79**	0.57**	0.56**	0.34**	-0.13	0.17*	-0.19*	-0.17*	0.54**	0.21	0.11
FW			1	0.83**	0.53**	0.20**	-0.27**	0.30**	-0.39**	-0.11	0.46**	0.35*	0.25
SW				1	-0.01	0.06	-0.31**	0.34**	-0.44**	0.01	0.51**	0.26	0.37*
F/S					1	0.25**	0.06	0.01	-0.01	-0.24**	0.05	0.32	0.01
FF						1	-0.05	0.08	-0.03	-0.15*	0.02	0.12	-0.07
*L**							1	-0.38**	0.91**	0.42**	-0.56**	-0.22	0.12
a*								1	-0.56**	-0.26**	0.60**	0.19	0.05
b*									1	0.44**	-0.60**	-0.34*	-0.04
TSS										1	-0.45**	-0.28	0.09
TA											1	0.02	-0.21
TEAC												1	0.65**

*: Correlations significant at P ≤ 0.05, **: Correlations significant at P ≤ 0.01

Principal component analysis

Principal component analysis was applied to obtain a more clear visualization of the whole data as previously used for fruit traits and genotypes of cherries (Drogoudi et al., 2009). The analyses were performed for pomological and phytochemical traits together, and 74.67% of the variability observed on the traits was explained by the first three components (PC1-PC3) (Table 6). In his study on local apricot genotypes, Yılmaz (2008) reported that first three components represented 73% of the total variance.

Composing most of the total variance, first three components were further investigated both for pomological and phytochemical traits. The rest of the components (PC4-PC14) varied to a lesser extent and they were not further considered in this study. Table 6 shows the correlations between the original variables and the first three principal components. Almost all of the evaluated parameters were mainly presented by PC1, accounts for 47.39% of the total variance, and TEAC and TPC were mainly presented by PC3, accounts for 11.10% of the total variance.

Table 6. Correlation matrix values among traits based on the first three principal components (PC)

Variables	PC1	PC2	PC3
FW	**0.93**	0.28	0.17
FL	**0.89**	0.37	-0.07
FLW	**0.88**	0.24	0.34
FVW	**0.87**	0.26	0.37
SW	**0.85**	0.15	0.03
b*	**-0.77**	0.50	0.27
*L**	**-0.69**	0.59	0.20
a*	**0.68**	-0.47	-0.19
TA	**0.64**	-0.47	0.24
TEAC	0.42	0.34	**-0.70**
TPC	0.22	0.59	**-0.68**
F/S	**0.50**	0.45	0.28
FF	**0.30**	-0.15	-0.12
TSS	**-0.46**	0.41	0.16

Components	Eigen Values	% Variance	Cumulative Variance %
PC1	6.63	47.39	47.39
PC2	2.27	16.18	63.57
PC3	1.55	11.10	74.67

The most important traits affecting the first component in principal component analysis were FW (0.93), FL (0.89), FLW (0.88), FVW (0.87) and SW (0.85), respectively, while the most important features affecting the second component were *L** (0.59) and TPC (0.59). The most important properties affecting the third component were determined as phytochemical properties such as antioxidant capacity (-0.70) and phenolic compound content (-0.68).

Component scores of the cultivars subjected to assessments were presented in Figure 1 for PC1 and PC2. Positive values of PC1 indicated cultivars characterized with their dominant characteristics of bigger fruit sizes, heavier fruit and stone weight, and higher F/S ratio. Roxana was characterized in this group. Positive PC1 with negative PC2 signed higher TA and a* value of which Tokaloğlu was characterized in that way. Positive values of PC2 with positive PC1 indicated a dominant character of TEAC and TPC, and Stark Early Orange and Hasanbey were characterized in this group. Positive values of PC2 together with negative PC1 scored cultivars which are characterized with their TSS, *L**, and b* values. Hacıhaliloğlu, Soğancı, Şekerpare, Çataloğlu, and Kabaaşı were accepted in this group.

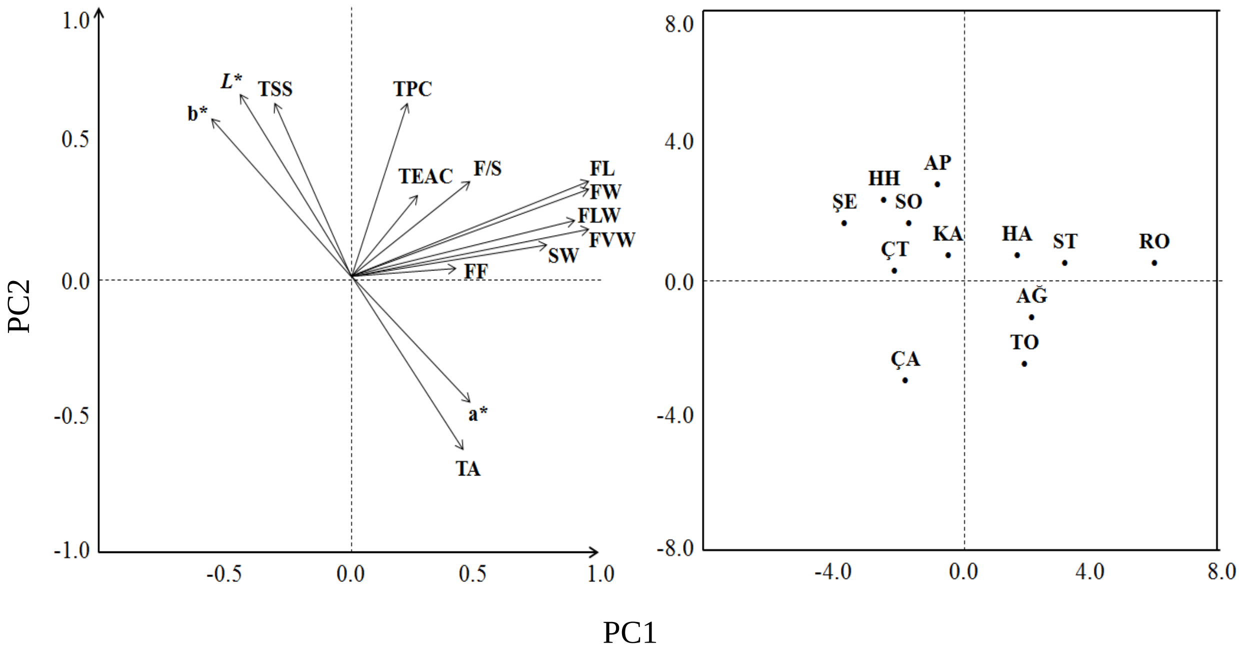

Figure 1. Segregation of apricot cultivars according to pomological and phytochemical characteristics determined by principal component analysis

Conclusions

Characterization of the genotypes and determination of relationships between phytochemical traits with other fruit quality characteristics are of importance in choosing cultivars rich in these compounds and in breeding studies as a guide in improving related traits. In this study, fruit samples of apricot cultivars which are widely cultivated in Turkey have been examined in terms of their pomological and phytochemical properties. The results confirmed the quantitative properties of the examined traits and showed a high degree of variability between the cultivars included in the study. As a result of the quantitative evaluations significant differences and a high variation were obtained between the cultivars in all examined traits. As a result of the study, it has been concluded that phytochemical properties of the apricot cultivars can be developed in advanced generations with the improvement programs to be carried out with an appropriate planning.

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References

Abbott, J. A., 1999, Quality measurement of fruits and vegetables, Postharvest Biology and Technology, 15: 207-225.

Anonymous, 2007, Apricot, TG/70/4 Rev.(proj.2). Union Internationale Pour la Protection des Obtentions Végétales (UPOV), http://www.upov.int/edocs/tgdocs/en/tg070.pdf Available Date: 20.04.2019.

Anonymous, 2014, Gıda, Tarım ve Hayvancılık Bakanlığı, Meyvecilik Araştırma Enstitüsü, Ilıman İklim Meyve Türlerinde Hasat Kriterleri, http://arastirma.tarim.gov.tr/marem/Belgeler/Yeti%C5%9Ftiricilik%20Bilgileri/Il%C4%B1man%20%C4%B0klim%20Meyvelerinde%20Hasat%20Kriterleri.pdf (Available Date: 20.04.2019).

Anonymous, 2018, Malatya Ticaret Borsası, http://www.malatyatb.org.tr/kayisi-fiyat---miktar-hareketleri (Available Date: 20.04.2019).

Asma, B. M., 2011, "Her Yönüyle Kayısı", Uyum Ajans, Ankara.

Asma, B. M, Ozturk, K., 2005, Analysis of morphological, pomological and yield characteristics of some apricot germplasm in Turkey, Genetic Resources and Crop Evolution, 52: 305-313.

Asma, B. M., Karaat, F. E., Çuhacı, Ç., Doğan, A., Karaca, H., 2017, Türkiye'de kayısı islah çalışmaları ve ıslah edilen yeni çeşitler, Türk Tarım - Gıda Bilim ve Teknoloji Dergisi, 5(11): 1429-1438.

Badenes, M. L., Martinez-Calvo, J., Llácer, G., 1998, Analysis of apricot germplasm from the European Eco-geographical group, Euphytica, 102(1): 93-99.

Bailey, C. H., Hough, L. F., 1979, "Apricots", In: Advances in Fruit Breeding, Purdue University Press, West Lafayette, Indiana, USA.

Bircan, M., Pınar, H., Yılmaz, C., Paydaş Kargi, S., Kaşka, N., Yıldız, A., 2010, The apricot breeding programme among some Turkish and foreign cultivars, Acta Horticulturae, 862: 103-108.

Caliskan, O., Bayazit, S., & Sumbul, A., 2012, Fruit quality and phytochemical attributes of some apricot (*Prunus armeniaca* L.) cultivars as affected by genotypes and seasons, Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 40(2): 284-294.

Dragovic-Uzelac, V., Levaj, B., Mrkic, V., Bursac, D., Boras, M., 2007, The content of polyphenols and carotenoids in three apricot cultivars depending on stage of maturity and geographical region, Food chemistry, 102(3): 966-975.

Drogoudi, P. D., Vemmos, S., Pantelidis, G., Petri, E., Tzoutzoukou, C., Karayiannis, I., 2008, Physical characters and antioxidant, sugar, and mineral nutrient contents in fruit from 29 apricot (*Prunus armeniaca* L.) cultivars and hybrids, Journal of Agricultural and Food Chemistry, 56(22): 10754-10760.

Ercisli, S., 2009, Apricot culture in Turkey, Scientific Research and Essays, 4: 715-719.

FAO, 2019, Food and Agriculture Organization Statistical Database (FAOSTAT), http://www.fao.org/faostat/en/#data/QC (Available Date: 17.04.2019).

Gökçen, İ. S., Kenkin, N., Kunter, B., Cantürk, S., Karadoğan, B., 2017, Üzüm fitokimyasalları ve Türkiye'de yetiştirilen üzüm çeşitleri üzerindeki araştırmalar, Turkish Journal of Forest Science, 1(1): 93-111.

Gurrieri, F., Audergon, J. M., Albagnac, G., Reich, M., 2001, Soluble sugars and carboxylic acids in ripe apricot fruit as parameters for distinguishing different cultivars, Euphytica, 117: 183-189.

Haffner, K., Vestreheim, S., 1997, Fruit quality of strawberry cultivars. Acta Horticulturae, 439(1): 325-332.

Hegedũs, A., Engel, R., Abrankó, L., Balogh, E., Blázovics, A., Hermán, R., Halász, J., Ercisli, S., Pedryc, A., Stefanovitsbányai, É., 2010, Antioxidant and antiradical capacities in apricot (*Prunus armeniaca* L.) fruits: Variations from genotypes, years, and analytical methods. Journal of Food Science, 75(9): 722-730.

INC, 2018, International Nuts and Dried Fruits Council 2016-2017 Statistical Yearbook, https://www.nutfruit.org/what-we-do/industry/statistics (Available Date: 20.04.2019).

Liu, R. H., 2013, Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals, The American Journal of Clinical Nutrition, 78(Suppl): 17–20.

Madrau, M. A., Piscopo, A., Sanguinetti, A. M., Del Caro, A., Poiana, M., Romeo, F. V., Piga, A., 2009, Effect of drying temperature on polyphenolic content and antioxidant activity of apricots, European Food Research and Technology, 228(3): 441-448.

McGuire, R. G., 1992, Reporting of objective color measurements, HortScience, 27(12): 1254-1255.

MGM, 2019. Resmi İstatistikler, T.C. Tarım ve Orman Bakanlığı, Meteoroloji Genel Müdürlüğü, https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx (Available Date: 17.04.2019).

Özgen, M., Reese, R. N., Tulio, A. Z., Miller, A. R., Scheerens. J. C., 2006, Modified 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) method to measure antioxidant capacity of selected small fruits and comparison to ferric reducing antioxidant power (FRAP) and 2,2'-diphenyl-1-picrylhydrazyl (DPPH) methods. Journal of Agricultural and Food Chemistry, 54: 1151-1157.

Radi, M., Mahrouz, M., Jaouad, A., Tacchini, M., Aubert, S., Hugues, M., Amiot, M. J., 1997, Phenolic composition, browning susceptibility, and carotenoid content of several apricot cultivars at maturity, HortScience, 32(6): 1087-1091.

Rice-Evans, C. A., Miller, N. J., Paganga, G., 1996, Structure-antioxidant activity relationship of flavonoids and phenolic acids. Free Radical Biology & Medicine, 20: 933-956.

Ruiz, D., Egea, J., 2008, Phenotypic diversity and relationships of fruit quality traits in apricot (*Prunus armeniaca* L.) germplasm, Euphytica, 163: 143-158.

Schmitzer, V., Slatnar, A., Mikulic-Petkovsek, M., Veberic, R., Krskab, B., Stampar, F., 2011, Comparative study of primary and secondary metabolites in apricot (*Prunus armeniaca* L.) cultivars. Journal of the Science of Food and Agriculture, 91(5): 860-867.

Slinkard, K, Singleton, V. L., 1977, Total phenol analysis: automation and comparison with manual methods, American Journal of Enology and Viticulture, 28(1): 49-55.

TUIK, 2018, Türkiye İstatistik Kurumu, Bitkisel Üretim İstatistikleri, https://biruni.tuik.gov.tr/medas/?kn=92&locale=en (Available Date: 17.04.2019).

Yılmaz, K. U., 2008, Bazı yerli kayisi genotiplerinin fenolojik, morfolojik ve pomolojik özellikleri ile genetik ilişkilerinin ve kendine uyuşmazlik durumlarinin moleküler yöntemlerle belirlenmesi, Phd Thesis, Institute of Science, Çukurova University.