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Morpho-pomological and Chemical Diversity of Pomegranate Accessions Grown in Eastern Mediterranean Region of Turkey

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ABSTRACT

Selecting within local pomegranate accessions is the main method used to identify new cultivars. Total of 76 pomegranate accessions from Hatay, Turkey, were collected and their morpho-pomological and chemical characteristics were determined. The results showed that there was significant diversity among the accessions in terms of fruit quality parameters. Several accessions were notable for their various characteristics. For example, 'Ekşi 5', 'Ekşiliknar', 'Kara Mehmet 1', 'Lifani 5' and 'Ekşi 3' accessions could be used for extracted aril and juice as they had dark red arils and juice, good taste, and large arils. In addition, the sweet accessions 'Tatlı 3', 'Tatlı 13', and 'Tatlı 16' with soft seeds, rosy peel, and red aril colors were very promising for fresh consumption. Our study demonstrated that there was great morpho-pomological variability among the local pomegranates grown in eastern Mediterranean region of Turkey, making them a valuable genetic source for incorporation into potential breeding programs, especially for different fruit quality characteristics.

Keywords: Chemical characters, Fruit quality, Principal component analysis, *Punica granatum.*

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INTRODUCTION

Punica granatum L. (Punicaceae) is one of the fruit trees that humans have been consuming for ages. As for many fruit species, pomegranate is valued for both its taste and beneficial effects on human health (Lansky and Newman, 2007) because of rich antioxidant content (Sadeghi *et al.*, 2009) such as anticarcinogens (Bell and Hawthorne, 2008), antimicrobials (Reddy *et al.*, 2007), and antivirals (Kotwal, 2007). In addition, it has been shown to reduce the risk of coronary heart disease and cancer mortality (Holland *et al.*, 2009).

Turkey is one of the main pomegranate producers among Mediterranean countries, where the majority of the pomegranate orchards are located in the Mediterranean, Aegean, and Southeastern regions of the country. Its annual production was about 208,502 tons in 2010 and the production is rapidly increasing year by year. Turkey's fresh pomegranate exports were 3,591 tons in 2000, 11,495 tons in 2005, and 61,223 tons in 2011 (TFFV, 2011).

Due to market request, it has become increasingly important to characterize the different cultivars and genotypes to identify those of high quality product that are economical to produce (Martínez *et al.*, 2006). Currently, commercial pomegranate cultivars grown in different countries are selections from local populations (Holland and Bar-Ya'kov, 2008) and a few examples include: 'Wonderful' in the USA, 'Hicaznar' in Turkey, and 'Mollar de Elche' in Spain (Stover and Mercure, 2007).

The origin of pomegranate is considered to be in Central Asia, especially parts of Iran in the Transcaucasia-Caspian region (such as

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Turkey, Azerbaijan, Georgia, and Iran) from where it has spread to the rest of the world (Levin, 2006). Thus, Turkey is a center of origin for pomegranate and has rich pomegranate genetic diversity. Local accessions are numerous and well adapted to different ecological conditions of Turkey. The accessions have been cultivated with traditional methods from ancient times until now and can be selected for adaptive characteristics such as resistance to diseases, pests, cold, and drought, etc. Therefore, the losses in genetic diversity in crop species due to commercialization have led the need to preserve the present genetic resources as much as possible for not only the long-term survival of the species, but also insuring enough variability for breeding programs (Esquinas Alcázar, 2005). Unfortunately, there are only a few researches dealing with morpho-pomological traits in pomegranate germplasm (Sarkhosh *et al*., 2009; Ferrara *et al*., 2011; Zaouay and Mars, 2011). Characterization based on morphological parameters is commonly used to solve duplication problems within germplasm collections (Zaouay and Mars, 2011). While morphological characters were generally influenced by environmental conditions and agronomic practices, their characterization is a highly recommended first step before starting biochemical or molecular studies (Berinyuy *et al*., 2002).

The Mediterranean region of Turkey has the most suitable ecological conditions for pomegranate growing, with 60% of the country's total pomegranate production. 'Hicaznar' cultivar is the most popular cultivar in different regions and has very appealing properties for consumers. With the rapid shift to a few cultivars such as 'Hicaznar', there is a concern that genetic erosion in pomegranate germplasm will occur as old diverse plantations are removed and replanted with 'Hicaznar' or succumb to urbanization.

The main objectives of this research were: i) to describe and compare pomegranate accessions grown in Hatay, the eastern Mediterranean region of Turkey, and ii) to determine the variability present within characters used in morpho-pomological and chemical studies.

MATERIALS AND METHODS

Plant Material

Seventy-six pomegranate accessions were sampled from Hatay in 2010-2011 growing seasons and were morphologically described. Nine traditional pomegranate locations in Hatay (Antakya, Altınözü, Belen, Dörtyol, Hassa, İskenderun, Kırıkhan, Samandağ, and Yayladağı) where pomegranates are cultivated under arid conditions were visited. This region has a typical Mediterranean climate; annual average temperatures of 8.2°C (min) and 27.7°C (max), with 1,078 mm precipitation which primarily falls during winter and spring, and 69% average annual relative air humidity. We conducted this study in Hatay since the province has a rich diversity of agro ecological conditions including: a 'subtropical climate' in the Mediterranean coastal zone, a 'plateau climate' in the Amanos Mountains, which has a maximum altitude of 2.240 m, and a 'temperate climate' in the Amik Plain. In addition, Hatay is situated on the ancient migration routes between Anatolia and the Middle Eastern countries and has been an important fruit production center of Turkey.

Morpho-pomological Analysis

Morpho-pomological identifications of the pomegranate accessions were conducted on samples of 15 fruits per accession. There were three replicates each consisting of five fruits. Maturity was determined based on visible fruit characteristics, mainly peel and aril colour and size (Hasnaoui *et al*., 2011; Zaouay and Mars, 2011). Harvesting date of the accessions were classified as 'early' (13–23 Sept.), 'medium' (24 Sept. – 04 Oct.), and 'late' (05 – 23 Oct.) based on methods

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described by Tibet and Onur (1999). Fruit weight (FW; g) and 100 aril weight (AW; g) were measured with a scale sensitive to 0.01 g (Precisa XB 2200 C, Precisa, UK). Fruit length (FL; mm) and diameter (FD; mm), calyx length (CL; mm) and diameter (CD; mm), and peel thickness (PT; mm) were measured by a digital caliper (Mitutoyo, 0–150 mm, Tokyo, Japan). Total aril weight was calculated by subtracting pericarp weight from total fruit weight, and then aril percentage was calculated by dividing total fruit weight by the total aril weight.

Seed hardness, taste, and visual colours were observed by five expert researchers. Seed hardness was scored based on a scale of 1-4 (1: Soft, 2: Semi-soft, 3: Semi-hard, and 4: Hard) (Sarkhosh *et al*., 2009). The arils were placed in one of the three classifications based on taste (1: Sweet, 2: Sour-sweet, and 3: Sour) described by Martínez *et al.* (2006). A colour scale ranging from greenish-yellow (1) to dark purplish-red (7) was used to evaluate peel color. The aril and juice colour was evaluated using a scale ranging from white (1) to dark red (7) (Bellini and Giordani, 1998).

Chemical Analysis

Four parameters were determined in the chemical analysis. Total soluble solid (TSS) content was determined with a hand-held refractometer (NOW, 0–32% Brix) and pH measurements were performed using a pH meter (WTW InoLab pH meter, Weilheim, Germany). Titratable acidity (expressed as citric acid %) was determined by titrating with 0.1 N NaOH to pH 8.10. Maturity Index (MI) was calculated as the ratio of total soluble solids to acidity. These values were classified as *MI*= 5-7 for 'sour', 17-24 for 'sour-sweet', and 31-98 for 'sweet' based on method described by Martínez *et al*. (2006). Besides, Antioxidant capacity (Pellegrini *et al*., 2003) total anthocyanin (Cheng and Bren, 1991), total phenolic (Slinkard and Singleton, 1977), and sugar contents (Camara *et al*., 1996) was evaluated for principle component analysis.

Statistical Analysis

All data were subjected to analysis of variance (ANOVA) using SAS (SAS, 2005). Means and ranges were calculated using PROC TABULATE. Principle component (PC) analysis was carried out using the PRINCOMP procedure. To evaluate dissimilarity among accessions, cluster analysis was carried out using the method of UPGMA (Unweighted Pair-group Method, Arithmetic Average). Data processing was performed using the NTSYS (Numerical Taxonomy System) program (Rohlf, 1998).

RESULTS AND DISCUSSION

Morpho-pomological Properties

Data showed a very large variability among pomegranate accessions for the given characteristics (Table 1). The most widely varied morpho-pomological characters were MI, acidity, aril, and juice color with coefficients of variation of 80.0, 70.1, 45.5, and 45.3%, respectively. The average FW of the pomegranates ranged from 69.9 ('Gıcıknar') to 795.3 g ('Katırbaşı 2'). The fruit size is one of the most important characters in the international markets for fresh consumption. Considering the fruit weight given by 'Pomegranate Descriptor', 65% of them were very large (> 375 g) and 29% were large (225-375 g). The mean fruit size (434.1 g) of the pomegranate accessions used in this study were higher than Greek (Drogoudi *et al*., 2005), Iranian (Sarkhosh *et al*., 2009; Tehranifar *et al*., 2010), Spanish (Martínez *et al*., 2006), Tunisian (Zaouay and Mars, 2011) and Italian (Ferrara *et al*., 2011) pomegranate accessions. This variation in fruit size among these studies can be attributed to cultivar, ecological conditions, as well as the amount of yield. For peel characteristics, there were big

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Table 1. Mean values, ranges and coefficients of variation for 18 qualitative and quantitative characters of pomegranate accessions.

Variable	Mean	Range	CV [a] (%)	SD [b]
Fruit weight (g)	434.1	69.9-795.3	34.3	10.6
Fruit diameter (mm)	91.5	48.6-117.8	12.9	0.9
Fruit length (mm)	82.0	56.5-99.6	12.0	0.7
Peel thickness (mm)	3.6	1.9-5.5	21.9	0.1
Calyx diameter (mm)	19.4	11.4-33.8	18.8	0.3
Calyx length (mm)	16.2	7.2-25.1	19.2	0.3
Aril weight (g 100 aril^{-1})	41.9	17.5-66.7	24.8	0.7
Aril percent (%)	61.3	47.9-72.0	8.8	0.5
Total soluble solids (%)	16.0	13.9-18.5	6.0	0.1
pH	3.1	2.6-3.9	9.9	0.0
Acidity (%)	1.4	0.2-4.4	70.1	0.1
Maturity index (TSS/acidity)	19.5	3.4-65.4	80.0	1.1
Seed hardness	3.0	1-4	28.9	0.8
Peel coverage color	3.0	1-5	32.2	0.9
Aril color	3.5	1-7	45.5	1.1
Juice color	3.4	1-7	45.3	1.5
Taste	1.9	1-3	38.1	1.2
Harvesting date (day)	9 Oct.	22 Sept-20 Oct		

[a] Coefficient of Variation = (Standard deviation/Mean)×100, [b] Standard Deviation.

differences among the accessions. They showed a range of 1.9-5.5 mm for peel thickness. The CD and CL varied widely, from 11.4 to 33.8 mm, and from 7.2 to 25.1 mm, respectively.

Pomegranate arils include juice, pulp, and the woody part which are all rich in raw fibers and other compounds. The aril size is one of the most important criterions for juice and fresh consumption of pomegranate (Ferrara *et al*., 2011). The AW values ranged from 17.5 ('Ekşi 15') to 66.7 ('Mayhoşnar 3') g 100 arils^{-1}. The AW values of the accessions were higher than those of Martínez *et al*. (2006), Sarkhosh *et al*. (2009), and Ferrara *et al*. (2011). The mean AP (61.3%) of the accessions was higher than that reported for Turkish and Italian cultivars which were 52.4 and 48.9%, respectively (Durgaç *et al*., 2008; Cristofori *et al*., 2011), but lower than Iranian cultivars (Varasteh *et al*., 2008). The morpho-pomological data, i.e. the fruit size, aril weight, and aril percent values reported in this study results were higher than important pomegranate cultivars/accessions grown in the different countries of world. These data could be critical for potential parent lines in future plant breeding.

Chemical and Sensory Characters

The TSS contents of the pomegranate accessions varied from 13.9% ('Tatlı 5') to 18.5% ('Ekşi 11) (Table 1). The mean TSS value of the accessions was 16.0%, very similar to Spanish, Iranian, and Italian cultivars (Martínez *et al*., 2006; Tehranifar *et al*., 2010; Ferrara *et al*., 2011). The acidity data showed a great variability with values ranging between 0.2 ('Tatlı 5' and 'Tatlı 12') and 4.4% ('Lifani 2'). In previous studies, acidity values were in the range of 2.1-2.4% for genotypes from Greece (Drogoudi *et al*., 2005), 0.4-2.5% from Italy (Cristofori *et al*., 2011; Ferrara *et al*., 2011), 0.3-2.4% from Iran (Tehranifar *et al*., 2010), 0.3-1.0% from Spain (Martínez *et al*., 2006), and 0.2-1.9% from Tunisia (Zaouay and Mars, 2011). The maximum acidity values of our accessions were higher than those reported for accessions from different countries, likely because of the early harvest of 'sour' accessions that are used for

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cooking and salads as a pomegranate sauce by people living in Mediterranean regions of Turkey.

The MI values of the accessions varied considerably from 3.4 in 'Lifani 2' to 65.4 in 'Tatlı 12'. The results were higher than that obtained for Iranian cultivars, 5.04 to 46.31 (Tehranifar *et al*., 2010) and for the new genotypes in Italy, 7.7 to 35.2 (Ferrara *et al*., 2011). According to the classification suggested by Martínez *et al*. (2006), the accessions were grouped in the class of 'sweet' (18 accessions), 'sour' (15 accessions), and 'sour-sweet' (43 accessions) by considering the MI contents. In contrast to this data, panelist evaluation resulted in slightly different numbers in the classes as 37 accessions in 'sour-sweet', 24 accessions in 'sweet', and 15 accessions in 'sour'.

Generally, seed hardness (SH) of pomegranate accessions were 'hard', but the SH was found 'soft' for 'Sayfi', 'Tatlı 3', 'Tatlı 6', 'Tatlı 12', Tatlı 13', and 'Tatlı 16' accessions with 'sweet' taste. Some of the commonly cultivated cultivars with sweet taste, soft seeds, and red or white aril color are 'Rosh Hapered' and 'Acco' in Israel (Holland and Bar-Ya'kov, 2008), 'Mollar de Elche' (ME1, ME2, and ME14) in Spain (Melgarejo *et al*., 2011), and 'Bihaste Dane Sefide Ravar', 'Bihaste Sangan', and 'Bihaste Shirin Saravan' in Iran (Sarkhosh *et al*., 2009). Peel and aril colors are an important fruit quality attribute in pomegranate marketing (Mena *et al*., 2011). Fruit peel coverage color (PCC) of the accessions was commonly reddish-yellow (35 accessions). The accessions 'Gavur Güzeli', 'Kara Mehmet 1', 'Kara Mehmet 2', 'Ekşi 3', 'Ekşi 5', and 'Tatlı 16' had the dark red aril and juice color. In addition, red aril color was found in the accessions 'Ekşi 12', 'Tatlı 2', 'Tatlı 3', 'Tatlı 4', 'Tatlı 13', and 'Tatlı 14'. This variation could originate from the differences in the studied genotypes maturity stage, agro-climatic, postharvest, and storage conditions (Sepulveda *et al*., 2010; Varasteh *et al*., 2012)

Harvest Date

Developing new and high quality pomegranate cultivars that have different harvest seasons is very important for marketing. In this study, the harvesting date (HD) of the pomegranate accessions ranged between 22 September and 20 October (Table 1). The HD of 'Kızılgöbek', 'Kızılgöbek Ekşi', and 'Körnar' accessions was 'early'; 'Antepnarı', Mayhoşnar 3', 'Nuznarı 2', 'Payasnarı', Lifani 1', 'Ekşi 14' and 'Ekşi 15' was 'mid-season'; and the rest of the accessions were 'late'. Generally, the FW of 'late' accessions were higher than 'early' accessions. Our harvesting periods were similar to the new Spanish genotypes: last week of September to last week of October (Martínez *et al*., 2006). These results were also in agreement with those of Holland and Bar-Ya'kov (2008), who reported that fruit weight of early ripening pomegranate cultivars were lower than medium and late ripening cultivars.

Maturity Index and Seed Hardness Groups

The mean *MI* values showed large variability with mean values of 44.5, 13.9, and 5.7 for 'sweet', 'sour-sweet', and 'sour' accessions, respectively. The pomegranate accessions were classified as 'sour', 'sour-sweet', and 'sweet' based on method described by Martínez *et al*. (2006). 'Sour-sweet' accessions had the highest average FW, AW, and AP (490 g, 45 g 100 aril^{-1}, and 62%, respectively) than 'sweet' and 'sour' accessions (Table 2). The TSS contents among all groups were similar, but acidity (range of 2.0-4.4%, mean 3.2%) and SH (range of 2.0-4.0, mean 3.6) values were higher for 'sour' group than the other groups. Our results were in agreement with Hasnaoui *et al*. (2011), who reported that pomegranate sourness or sweetness was due to high or low values of citric acid regardless of their sugar contents. The PCC

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Table 2. Range and mean of some important characteristics for pomegranate accessions sampled from Hatay, Turkey. The accessions were grouped depended on maturity index (MI) and seed hardness (SH).

Character for MI	FW[a] (g)		AW[b] (g 100aril^{-1})		AP[c] (%)		TSS[d] (%)		Acidity (%)		SH[e]		PCC[f]		AC[g]	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Sweet	261–601	387	40–60	41	60–70	61	16–19	16	0.4–1.6	0.4	2.6–3.0	2.6	3.2–5.0	3.3	3.1–7.0	3.3
Sour-sweet	195–795	490	25–67	45	49–74	62	14–18	16	0.6–2.8	1.3	1.0–4.0	2.9	2.0–5.0	3.1	1.0–7.0	3.5
Sour	70–593	315	18–54	33	48–66	60	14–18	16	2.0–4.4	3.2	2.0–4.0	3.6	1.0–5.0	2.5	2.0–7.0	4.0
Character for SH																
Soft	308–471	395	32–60	41	52–64	60	15–16	16	0.2–0.4	0.3	27.2–65.4	48.9	2.0–3.0	2.7	1.0–7.0	4.2
Semi-soft	255–665	493	26–58	44	49–74	60	14–18	16	0.6–2.5	1.5	6.6–10.6	13.5	2.0–5.0	3.0	2.0–7.0	4.7
Semi-hard	261–795	471	25–67	43	51–70	62	14–19	16	0.2–3.2	1.1	4.8–63.0	20.6	1.0–5.0	3.1	1.0–7.0	3.3
Hard	70–691	343	18–62	38	48–72	61	14–18	16	0.3–4.4	2.3	3.4–54.2	11.8	1.0–5.0	2.9	2.0–7.0	3.1

[a] Fruit Weight; [b] Aril Weight/100 aril; [c] Aril Percent; [d] Total Soluble Solids; [e] Seed Hardness; [f] Peel Coverage Color; [g] Aril Color.

was the highest in ‘sweet’ group, whereas AC and JC were the highest in ‘sour’ group.

The SH is very important for fresh consumption. The pomegranate accessions were grouped into four different SH categories according to “the Descriptor” established by Sarkhosh *et al*. (2009). The accessions with ‘semi-soft’ seed had the highest FW (range of 255-665 g, mean 493 g) and AW (range of 26-58 g 100 aril^{-1}, mean 44 g 100 aril^{-1}) while the accessions with ‘hard’ seed had the lowest FW (range of 70-691 g, mean 343 g) and AW (range of 18-62 g 100 aril^{-1}, mean 38 g 100 aril^{-1}) (Table 2). The average AP and TSS values for the accessions were similar among different groups. The accessions with ‘hard’ seed (2.3%) had the highest acidity whereas the accessions with ‘soft’ seed (0.3%) had the lowest. Perfect MI values were observed in the accessions with ‘semi-soft’ (range of 6.6-29.9, mean 13.5) and ‘hard’ (range of 3.4-54.2, mean 11.8) seeds. The SH with ‘semi-soft’ also had the highest FW and AW, and an excellent MI value. The PCC was similar among the accessions with different SH, whereas the accessions with ‘semi-soft’ had the highest AC (4.7; rose-red).

Principal Component Analysis

The PCA results showed that there was great variation among the accessions depending on the morpho-pomological and chemical parameters. The first three PCs explained 50.5% of the total variation, with 22.5, 16.8, and 11.2%, respectively. We considered as values above 0.24 to be significant for important parameters (Table 3). The important variables composed in PC1 were: FW, FD, FL, AW, pH, acidity, MI, taste, TP, and FRUC. The FW, FD, FL, AW, PT, MI, TA, FRUC, and GLUC were the variables included in PC2. The pH, AC, JC, and TA were the most important variables for PC3. Most of these variables were related to morpho-pomological parameters emphasizing the importance of

Table 4. Eigen values and cumulative variance of the first three principle component (PC) analysis for the morpho-pomological and chemical characteristics in the pomegranate accessions.

Principal components	PC1	PC2	PC3
Eigen value	5.4	4.0	2.6
Variance (%)	22.5	16.8	11.2
Cumulative variance (%)	22.5	39.3	50.5
Characters			
Fruit weight	**0.31**	**0.28**	0.19
Fruit width	**0.32**	**0.27**	0.18
Fruit length	**0.30**	**0.28**	0.17
Peel thickness	0.10	**0.27**	–0.04
Calyx width	0.22	0.08	0.18
Calyx length	–0.01	0.21	–0.08
Aril weight	**0.27**	0.22	0.03
Aril percent	0.10	0.11	0.09
Total soluble solids	–0.07	–0.10	0.23
pH	**0.26**	–0.18	**–0.27**
Acidity	**–0.36**	0.18	0.15
Maturity index	**0.26**	**–0.25**	–0.23
Harvest date	0.15	0.02	0.17
Seed hardness	–0.22	0.15	–0.12
Peel coverage color	–0.02	–0.15	–0.01
Aril color	–0.04	–0.17	**0.49**
Juice color	–0.04	–0.21	**0.46**
Taste	**–0.31**	0.23	0.19
Total phenolics	–0.13	**–0.24**	0.08
Total anthocyanins	0.03	–0.19	**0.25**
Total antioxidant capacity	0.09	–0.01	0.06
Fructose	**0.26**	**–0.28**	0.03
Glucose	0.21	**–0.26**	0.05
Sucrose	0.06	–0.16	0.13

correct fruit characterization to identify pomegranate accessions. Actually, fruit and aril weight, fruit length, fruit diameter, fruit peel color, peel thickness, TSS, acidity (Drogoudi *et al*., 2005; Sarkhosh *et al*., 2009; Zaouay and Mars, 2011), maturity index (Durgaç *et al*., 2008; Sarkhosh *et al*., 2009), calyx diameter and length (Sarkhosh *et al*., 2009) are the most important variables in pomegranate characterization. The results confirmed the usefulness of the conventional characters used by different researchers to evaluate pomegranate genetic resources. In addition, total anthocyanin, total phenolics, fructose, and glucose contents of the pomegranate fruits were found to be very important properties for the diversity of accessions.

Morpho-pomological Diversity

The UPGMA dendrogram obtained with 24 objective and subjective measurements for the 76 pomegranate accessions, are shown in Figure 1. The accessions were clustered into four main groups. Group 1 consisted of 10 accessions of which 'Ekşi 2' and 'Tatlı 8' showed very similar fruit characters. The accessions in this group had small fruit size. Group 2 (11 accessions) including 'Lifani 5' and 'Ekşi 14', 'Tatlı 9', and 'Tatlı 11' had similar fruit size and taste.

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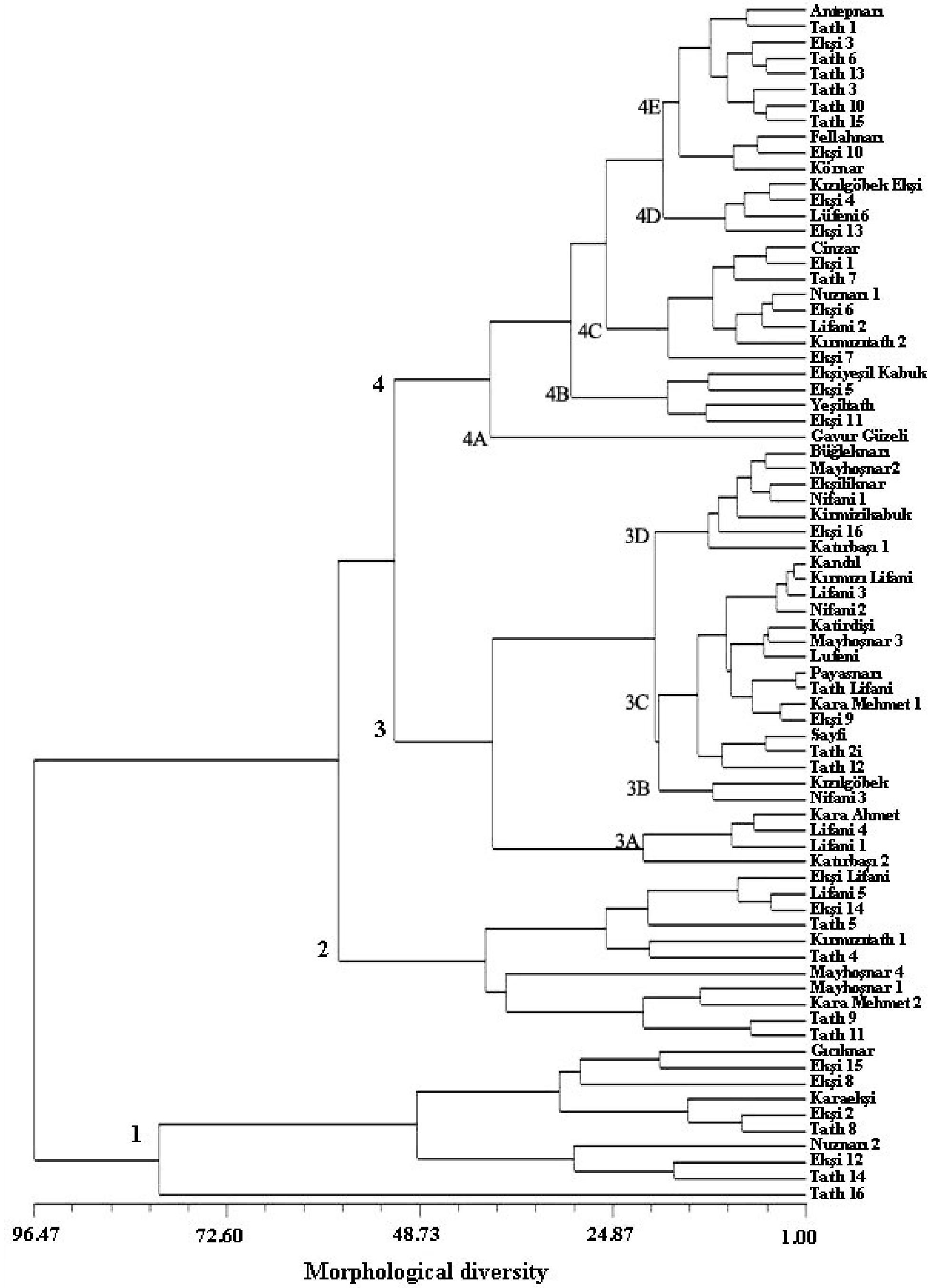

Figure 1. UPGMA dendrogram based on morpho-pomological distances of pomegranate accessions sampled from Hatay, Turkey.

Group 3 included 23 accessions and were separated into four subgroups (3A to 3D) based on different pomological characteristics such as fruit size, AW, AP, and taste. Subgroup 3A, which included 'Kara Ahmet', 'Lifani 4', 'Lifani 1', and 'Katırbaşı 2', had large fruit size, AW, AP, TP, and TAC. Subgroup 3B consisted of 2

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accessions of which 'Kızılgöbek' and 'Nifani 3' showed similarity for fruit size, pH, acidity and SH. Subgroup 3C consisted of 14 accessions with different fruit taste. 'Sayfi', 'Tatlı 2', and 'Tatlı 12' had 'sweet' fruit taste. Generally, the accessions in this subgroup had large fruit size. 'Kandıl' and 'Kırmızı Lifani', 'Payas' and 'Tatlı Lifani' with a 'sour-sweet' taste were very similar to each other. 'Büğleknarı', 'Mayhoşnar 2', 'Ekşiliknar', Nifani 1', 'Kırmızıkabuk', 'Ekşi 16', and 'Katırbaşı 1' accessions with 'sweet', 'sour-sweet' and 'sour' fruit taste were classified in the same subgroup (Group 3D). These accessions also had large fruit sizes and high AW, AP, TSS, and pH. Group 4 included 28 accessions that could be divided into five subgroups (4A to 4E). Only 'Gavur Güzeli' with red skin and aril color was in subgroup 4A. This accession had small fruit size, AW, and higher TTS and acidity than the others. The subgroup 4B consisted of four accessions of which 'Ekşiyeşil Kabuk' and 'Ekşi 5' and 'Yeşil Tatlı' and 'Ekşi 11' showed similar fruit characters. 'Cinzar', 'Ekşi 1', 'Tatlı 7', 'Nuznarı 1', 'Ekşi 6', 'Lifani 2', 'Kırmızı Tatlı 2', and 'Ekşi 7' with reddish-yellow and red fruit skin colors and small size fruits were classified in the same subgroup (4C). The subgroup 4D consisted of four accessions of which 'Kızılgöbek Ekşi' and 'Ekşi 4' showed very similar pomological characters such as TSS, pH, PCC, AC, and JC. The subgroup 4E included 11 accessions of which 'Tatlı 6' and 'Tatlı 3', and 'Tatlı 10' and 'Tatlı 15' had very similar fruit size, AP, TSS, acidity, AC, and phytochemical parameters. Generally, the accessions in this subgroup had a 'sweet' fruit taste, except for 'Ekşi 3'. 'Fellahnarı', 'Ekşi 10', and 'Körnar' with 'sour' fruit taste were separated from the 'sweet' accessions in this subgroup.

Principal component and cluster analysis indicated that there were great variations among accessions in terms of morpho-pomological and chemical attributes. Accessions with similar characteristics sampled from different locations were clustered in the same groups. This result may be due to similarities, homonymies, and synonymies appear to be common in pomegranate, and that different names probably are emerged through the transport of plant material among locations in the eastern Mediterranean region of Turkey. We know that the morphological properties are one of the most essential variables for pomegranate researches, but the outcome obtained from these sorts of studies has been limited due to the inconvenience in establishment of reference accessions in pomegranate breeding programs. To overcome these limitations, large-scale DNA-based PCR methods using amplified fragment length polymorphism (AFLP) (Ercisli *et al*., 2011; Nemati *et al*., 2012), randomly amplified polymorphic DNA (RAPD) (Zamani *et al*., 2007; Sarkhosh *et al*., 2009; Hasnaoui *et al*., 2010a; Noormohammadi *et al*., 2012), and simple sequence repeat (SSR) markers have been successfully designed for pomegranate (Hasnaoui *et al*., 2010b; Soriano *et al*., 2011; Parvaresh *et al*., 2012; Noormohammadi *et al*., 2012). Complete morpho-pomological and chemical characterization together with molecular characterization will allow optimizing pomegranate germplasm management to distinguish synonyms and homonyms and to study conserved diversity (Noormohammadi *et al*., 2012).

'Wonderful', (USA and Israel), 'Rosh Habered' and 'Acco' (Israel), 'Mollar de Elche' (Spain), 'Bagua' (India), 'Hicaznar' (Turkey), 'Manafaluty' (Egypt), and Iranian cultivars ('Malas-e-Torsh-e-Saveh', 'Rabab-e-Neiriz', 'Malas-e-Yazdi', 'Shishe-Cap-e-Ferdows', and 'Naderi-e-Natanz) are commonly cultivated in the world (Stover and Mercure, 2007; Varasteh *et al*., 2009). However, the number of cultivars that combine most of the desired features including good taste and color, high content of antioxidant and anti-cancer compounds and resistance to major pest and diseases are limited (Holland and Bar-Ya'kov, 2008). The full potential of natural variation of pomegranates is not yet fully appreciated,

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neither the list of available cultivars that could be serving as potential parent lines in breeding studies (Holland and Bar-Ya'kov, 2008). Therefore, there is a need to identify local pomegranate cultivars for both finding out promising cultivars and determining the breed lines. The eastern Mediterranean regions of Turkey have numerous local pomegranate cultivars with a range of sizes, ripening times, peel and aril colors, and tastes. The morpho-pomological and chemical characterization and protection of this genetic diversity for future plant breeding and germplasm evaluation studies are highly important.

CONCLUSIONS

A tremendous diversity in local pomegranate accessions was found based on this evaluation of morpho-pomological and chemical characteristics. Several accessions suitable for fresh fruit and aril consumption or juice were identified. 'Ekşi 5' was very promising for fresh consumption based on fruit quality characters. 'Ekşiliknar', 'Kara Mehmet 1', 'Lifani 5', and 'Ekşi 3' can be used for extracted aril and juice with dark-red-aril and juice color, good taste, and aril size. However, morpho-pomological and chemical characters affected by environment conditions are not effective at distinguishing homonymies and synonymies accessions. Therefore, further studies are needed towards determining different parameters regarding morpho-pomological and chemical traits to be used with molecular markers.

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تنوع صفات میوه وریخت شناسی نمونه های انار در منطقه شرقی مدیترانه در ترکیه

ا. کالیسکان، و س. بایازیت

چکیده

روش اصلی برای شناسایی ارقام جدید انار گزینش از میان نمو نه های محلی است.در این پژوهش، تعداد ۷۶ نمونه انار از منطقه هاتای ترکیه گرد آوری شد و صفات میوه و ریخت شناسی و ویژگی های شیمیایی آنها تعیین شد.نتایج حاکی از تنوع قابل توجه پارامترهای کیفی میوه در نمونه ها بود. شماری از ارقام ویژگی های قابل ملاحظه ای داشتند. برای مثال، ارقام 'Ekşi 5', 'Ekşiliknar', 'Kara Mehmet 1', 'Lifani 5' و 'Ekşi 3' را می توان برای آب گیری و خوردن دانه به کار برد زیرا رنگ آب ودانه های آنها قرمز تند، طعم خوب ودانه ها درشت است.افزون بر این،ارقام 'Tatlı 3', 'Tatlı 13', 'Tatlı 16' شیرین بوده و دانه های نرم وقرمز وپوستی به رنگ قرمز دارند که برای مصرف تازه خوری خیلی مناسب هستند. پژوهش ما نشان داد که تنوع زیادی در صفات میوه وریخت شناسی انارهای محلی منطقه شرق ی دریای مدیترانه در ترکیه وجوددارد و به لحاظ این تنوع، آنها منبع ارزشمندی برای برنامه های بهنژادی به ویژه در زمینه بهبود کیفیت ویژگی های میوه می باشند.