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MORPHO-POMOLOGICAL DIVERSITY OF TURKISH PEAR (*Pyrus communis* L.) ACCESSIONS IN EASTERN MEDITERRANEAN REGION OF TURKEY

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Abstract. Conservation and sustainable use of plant genetic resources is important to meet the demand for future food security. This study was conducted on twenty-five native pear accessions sampled from Hatay, province, in eastern Mediterranean region of Turkey. In these accessions, ripening time, productivity, and some important pomological traits were determined such as fruit weight, fruit sizes, total soluble solids contents, pH, and acidity. The grittiness, flavor, and juiciness were also measured as sensory analysis. These results showed that the earliest ripening among the all studied accessions were 'Biçin 1' and 'Biçin 2' (June 25 in 2009 and June 23 in 2010), while the latest accessions were 'Dağarmudu 1' and 'Dağarmudu 2' (November 8 in 2009 and November 5 in 2010). In pear accessions, productivity was identified as medium and high. The fruit weight of pear accessions were ranged between 28.29 and 160.02 g, seed numbers were ranged between 0.56 and 10.00, total soluble solid contents were ranged between 10.00 and 18.50%. In pear accessions, 15 instead of all 21 of morpho-pomological fruit properties were able to explain 85.0% of the total variation. As a result, some pear accessions may be recommended for both pear cultivation and the breeding studies in terms of earliness and flavor.

Key words: *Pyrus communis*, ripening time, yield, fruit properties, fruit color

INTRODUCTION

Pear (*Pyrus communis* L.) stands second after apples as the most frequently consumed fruit and is one of the most economically important tree fruit species in temperate zones of the world. Overall, world pear production reached to 22.638 million tonnes

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in 2010 [FAO 2011]. According to the FAO report on the state of world's plant genetic resources for food and agriculture at least 1140 pear accessions are present in worldwide ex-situ collections [Martinelli et al. 2008]. According to recent data pear production in Turkey is 380.000 tones [Anonymous 2010] and the genetic resources of pear are abundant, with more than 640 cultivars had been reported [Özbek 1978].

There has been concern for a quite long time that plant genetic resources are endangered all over the world because of continuous land development and climate change. Conservation of genetic diversity is important not only for wild species but also for cultivated plant species. Monoculturalization has already driven out many local cultivars so the collection, conservation, evaluation, and propagation of local or old cultivars and wild relatives are urgently required before their extinction [Katayama and Uematsu 2006]. Several of the local cultivars were low-input cultivars but showed adaptation to the local environmental conditions and the harvest was relatively stable, even under extreme conditions. The high genetic variability between and within different populations determined a poor annual harvest compared to the modern cultivated cultivars, but in turn this diversity often protected people from complete loss of the harvest [Hammer et al. 2003].

Plant genetic resources of cultivated fruit plants as well as wild relatives have significant values to mankind as they provide food, rootstock. Further, plant breeders require genetic variation (genotypes) for plant improvement. Genetic diversity in local cultivars and wild relatives is very important, as they contain agronomically important genes underlying many traits such as resistances to biotic and abiotic stresses. Thus, all unique accessions need to be collected, characterized and preserved [Engelmann 1991]. From this point of view, the characterization of *Pyrus* species germplasm is a topic of great important emphasized in many works [Rotondi et al. 2003, Agrimonti et al. 2007, Weiguo et al. 2007, Katayama and Uematsu 2006, Bao et al. 2008, Brini et al. 2008]. So far, various studies have been conducted for the identification of pear genetic resources in different regions of Turkey [Yarılgaç and Yildiz 2001, Karlıdağ and Eşitken 2006, Özrenk et al. 2010] and important biological, pomological and technological traits of both fruit and tree have been reported. They further showed that the selected cultivars could be used both for breeding programmes and as rootstock researches, as well as in further disease resistance studies under field and laboratory conditions. With this perspective we carried out a survey of the local germplasm of pear from Hatay province, in eastern Mediterranean region of Turkey. In this region, pear cultivation is still carried out traditionally due to the importance of this species for the economy of the region and the fruits are used as fresh production.

The Hatay province is rich of diversity of genus *Pyrus* and other temperate and subtropical fruits, and its mountainous and plain areas are very suitable as agro-ecologically for the production of these fruits. Due to geographical diversity, unevenness, naturalized population and inter-specific cross pollination, the region represents high degree of genetic diversity for fruit plants. The wide adaptation of the pear genotypes has great variability in their fruit quality. Therefore, characterization for all existing variation within genotypes is of vital importance. Fruit quality (fruit and chemical characteristics) have not yet been fully characterized for the local pear genotypes found in the region, which is important in assessing potential for their commercialization.

The aim of the study was to characterize based on morpho-pomological parameters and screen out the plant material for horticultural interest. The promising genotypes can be promoted for nursery trade, fruit production for both fresh consumption and processing, and to use in breeding pears.

MATERIALS AND METHODS

Twenty-five local pear accessions from Hatay province in eastern Mediterranean region of Turkey were analyzed in this study (tab. 1). Individual trees in villages of the region were selected according to economically valuable characters. Trees were sampled from their planted locations and not placed in a common orchard. The trees were approximately 25–50 years old and grafted on seedling or wild pear (*Pyrus elaeagrifolia* Pall.) rootstocks. Cultural practices such as irrigation, fertilizer application, weed control, pruning, spraying etc. were not implemented in these accessions.

Data were collected for two years (2009–2010). All accessions were examined for a set of 18 traits. Morpho-pomological characters were measured on fruit at full maturity stage and were sampled forty fruits per tree. Ripening time and yield were determined then the following traits were characterized for each local pear accessions.

Pomological characteristics. The pomological methods used in this study has been described by Dumanoglu et al. [2006]. Fruit weight (g) was measured with a scale sensitive to 0.01 g (Precisa XB 2200 C). Fruit length (mm) and diameter (mm), stalk length (mm) and diameter (mm) were measured by a digital caliper (Mitutoyo, 0–150 mm). Flesh firmness was tested on two sides of each fruit by an Effegi penetrometer with a 7.8 mm plunger after removal of the peel and then it was measured as libre. These values were classified as < 5 for 'soft', 6–8 for 'intermediate', and > 9 for 'hard' based on method described by Chauvin et al. [2010]. Skin color was measured on opposite sides of the fruit using a Minolta chromameter (model CR-300; Minolta Camera Co., Osaka, Japan), which provided CIE L* a* b* values. The values were used to calculate hue angle ($h°$ = arctangent [b*/a*]), where 0° = red-purple; 90° = yellow; 180° = bluish-green, and 270° = blue and chroma (C) value, calculated as $C = (a^2 + b^2)^{1/2}$, indicates color intensity [McGuire 1992]. Total soluble solids (TSS) content were determined with a hand-held refractometer (NOW, 0–32% Brix) and pH (WTW InoLab pH meter) measurements were performed using a pH meter. Acidity (expressed as malic acid %) was determined by titrating with 0.1 N NaOH up to pH 8.10.

Sensory analyses. Samples of 10 fruits were used in sensory analyses, which were conducted by 5 panelists. Productivity, grittiness, and flavor were scored as low, intermediate, and high and texture was scored as extremely coarse, coarse, intermediate, fine, and extremely fine. Juiciness was evaluated as juicy, intermediate, and low [CEC and IPGRI 1983].

Statistical analysis. All data were subjected to analysis of variance (ANOVA) using SAS [2005]. Means and standard deviations were calculated using PROC TABULATE. Principle Coordinate (PC) Analysis was carried out using the PRINCOMP procedure and the accessions were plotted on the first five PCs. To evaluate similarity 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 [Rholf 1998]. Due to the use of different measure units resulted in completely different types of scales, which had the unequal weight, the data were standardized so that each variable has a mean of 0 and a standard deviation of 1. The standardization enabled all characters to a comparable scale.

Table 1. Geographic coordinates of pear accessions collected from Hatay, in eastern Mediterranean region of Turkey

Accession number	Accession name	Longitude (N)	Latitude (E)	Altitude (m)
1	Baldırıbüyük	35°58'61"	36°09'89"	536
2	Bardak	35°58'15"	36°01'14"	807
3	Biçin 3	35°58'01"	36°09'38"	605
4	Dağarmudu 1	36°07'36"	36°12'30"	413
5	Dağarmudu 2	36°07'35"	36°12'30"	416
6	Dermişirin 1	35°58'78"	36°01'19"	629
7	Dermişirin 2	35°58'71 "	36°01'24"	766
8	Dermişirin 3	36°01'32"	36°03'40"	604
9	Harman 1	36°01'44"	36°08'52"	775
10	Harman 2	36°01'46"	36°08'39"	799
11	Karbeyaz 1	36°04'81"	36°16'28"	357
12	Karbeyaz 2	36°04'81"	36º 16'28"	357
13	Kokarmiski	35°58'28"	36°01'32"	799
14	Kuşboku 1	35°58'95"	36°01'50"	799
15	Kuşboku 2	35°58'95"	36°01'50"	799
16	Kuşboku 3	35°58'16"	36°01'16"	809
17	Şekerpare 1	35°57'93"	36°10'12"	504
18	Şekerpare 2	35°57'93"	36°10'12"	504
19	Şekerpare 3	35°57'93"	36°10'13"	505
20	Tokdemir	36°06'16 "	36°16'18"	312
21	Tip 1	35°58'06"	36°10'16"	510
22	Tip 2	35°58'94"	36°01'51"	807
23	Biçin 1	35°58'56"	36°09'72"	546
24	Biçin 2	35°58'54"	36°09'76"	528
25	Kokulu	35°58'60"	36°09'86"	525

RESULT AND DISCUSSION

Turkey is one of the center of origin of pear accessions. Local cultivated accessions are numerous and well adapted to different ecological conditions. Their denominations are mainly local originating from the fruit size (e.g. ‘Baldırıbüyük’, ‘Bardak’), flavor (e.g. ‘Şekerpare’, ‘Dermişirin’), or ripening time (e.g. ‘Biçin’, ‘Harman’).

The accessions with their ripening time, productivity and organoleptic properties were presented in Table 2. Ripening time of the local pear accessions varied based on

accessions and years, and it was from June 25 to November 8 in 2009, and from June 23 to November 5 in 2010. Pereira-Lorenzo et al. [2012] reported that ripening times of 115 Spanish local pear accessions were ranged between 16 August and 14 September. In our study, ripening time of 13 pear accession changed between 25 June and 20 July (tab. 2). Therefore, these accessions can be used for earliness breeding programs. Productivity was estimated on visual basis per accession. Out of 25 accessions studied, 14 accessions (57%) were found highly productive and 11 accessions (43%) were in the middle.

The fruit quality is determined by mean fruit weight and fruit dimensions, internal composition such as contents of sugars, acids, minerals and other characteristics like aroma, texture and flavor [Kappel et al. 1995]. Changes in taste, firmness, and appearance of the fruits can be consequences of changes in sugar contents, sugars acid ratio, organic acids etc. All these qualities of fruits depend on plant genotypes, soil and environmental conditions as well as maturity and time of harvesting [Hudina and Stampar 2005]. Variation in harvesting dates causes variation in fruit composition and ultimately the quality of fruits. According to Mellenthin et al. [1980] and Boonyakiat et al. [1987], earlier harvested fruits had low decay incidence but developed poor dessert quality, especially poor flavor; whereas late harvested had highest incidence of decaying, soften and tended to develop courser texture than optimum harvested fruits particularly in case of pear.

In the present study, the early accessions ‘Biçin 1’ ‘Biçin 2’, ‘Biçin 3’, ‘Karbeyaz 1’, Karbeyaz 2’, ‘Kokarmiski’, ‘Şekerpare 1’, ‘Şekerpare 2’, ‘Şekerpare 3’, ‘Tokdemir’, and ‘Kokulu’ showed excellent fruit quality traits with sweet flavor, low or no grittiness and fine texture. The several accessions were similar with respect to quality of fruits whereas some accessions were entirely different, grown in similar ecological conditions. This diversity among accessions was observed by the panelists. The data were consistent with the results reported by Brown and Walker [1990] and Chen et al. [2007] who found that different pear cultivars had different chemical compositions and different relationships between fruit quality variables. Pomological properties of the twenty-five pear accessions were shown in Table 3 and 4. The highest fruit weight was found in ‘Baldırıbüyük’ (160.2 g) and ‘Bardak’ (153.58 g). Considering the fruit weight given by Martinelli et al. [2008], 8% of them were big (150–300 g) and 92% of them were small (< 100 g). The accessions ‘Baldırıbüyük’ and ‘Bardak’ had the big fruit sized with the highest length and diameter values, while ‘Dağarmudu 1’, ‘Dağarmudu 2’, ‘Dermişirin 1’, and ‘Tip 1’ had the smallest fruit size (tab. 3).

Fruit size is an important marketing parameter, determining economical value in horticultural crops especially for pears and apples [Gillaspy et al. 1993, Pereira-Lorenzo et al. 2003]. It is also an important parameter for selection of superior genotypes through breeding programmes [Westwood and Blaney 1963]. Ahmed et al. [2011] indicated that early maturing cultivars might have small sized fruits as compared to late maturing cultivars due to less time available for fruit growth and development. In the present study, the accessions showed variability in their fruit sizes. In the other studies, the ranges of fruit weight values for pear accessions were, 237.76 and 368.02 g, 7.9 and 38.8 g, 70.98–211.03 g, 20.07 to 199.00 g, respectively [Yarılgaç and Yıldız 2001, Milutinovic et al. 2004, Karlıdağ and Eşitken 2006, Özrenk et al. 2010]. Previous stud-

ies conducted on pear cultivars revealed that, fruit length and fruit width ranged from 60.66 to 91.40 mm and 59.14 to 70.98 mm, 29.24 to 87.29 mm and 31.44 to 71.77 mm, respectively [Karlıdağ and Eşitken 2006, Özrenk et al. 2010]. Our results were lower compared to these studies. The variation of fruit weight, fruit length and fruit width of pears can be due to different cultivars, rootstocks, yield, environmental conditions and nutritional status of orchards as well.

Table 2. Ripening time, productivity and sensory properties of local pear accessions sampled from Hatay, Turkey

Accession name	Ripening Time		P	F	J	G	T
	2009	2010					
Baldırıbüyük	1 Sept.	27 Aug.	int	sweet	juicy	int	fine
Bardak	1 Sept.	27 Aug.	int	sweet	juicy	low	fine
Dağarmudu 1	8 Nov.	5 Nov.	high	int	low	high	ext coarse
Dağarmudu 2	8 Nov.	5 Nov.	int	int	low	high	ext coarse
Dermişirin 1	18 Aug.	24 Aug.	int	int	juicy	high	coarse
Dermişirin 2	29 Aug.	1 Sept.	int	int	juicy	high	coarse
Dermişirin 3	29 Aug.	1 Sept.	int	int	juicy	high	coarse
Harman 1	18 Aug.	27 Aug.	high	sweet	juicy	int	int
Harman 2	18 Aug.	27 Aug.	high	sweet	juicy	int	int
Karbeyaz 1	5 July	1 July	high	sweet	juicy	low	fine
Karbeyaz 2	5 July	1 July	high	sweet	juicy	low	fine
Kokarmiski	3 July	1 July	high	sweet	juicy	low	ext fine
Kuşboku 1	8 Aug.	20 July	int	sweet	juicy	int	fine
Kuşboku 2	8 Aug.	20 July	int	sweet	juicy	int	fine
Kuşboku 3	8 Aug.	20 July	int	sweet	juicy	int	fine
Şekerpare 1	5 July	1 July	high	sweet	juicy	low	fine
Şekerpare 2	5 July	1 July	high	sweet	juicy	low	fine
Şekerpare 3	5 July	1 July	high	sweet	juicy	low	fine
Tokdemir	5 July	1 July	high	sweet	juicy	low	int
Tip 1	5 July	1 July	int	sweet	juicy	low	int
Tip 2	20 July	20 July	int	sweet	juicy	low	int
Biçin 1	25 June	23 June	high	sweet	juicy	low	fine
Biçin 2	25 June	23 June	high	sweet	juicy	low	fine
Biçin 3	1 July	1 July	high	sweet	juicy	low	fine
Kokulu	5 July	1 July	high	sweet	juicy	low	fine

P – Productivity, F – Flavor, J – Juiciness, G – Grittiness, T – Texture, Int – Intermediate, Ext – Extremely

In this study, stalk lenght, stalk thickness and seed number varied depending on the pear accessions. Fruit stalk length was ranged from 14.75 to 42.30 mm, while stalk thickness was ranged from 2.13 mm to 10.26 mm. The average seed numbers per fruit were changed between 0.6 (‘Baldırıbüyük’) to 10.0 (‘Biçin 3’). Milutinovic et al. [2004] reported that the seed numbers per fruits of the studied genotypes of pear varied from 2.3 to 9.5. Our results were similar to data obtained by Milutinovic et al. [2004].

Table 3. Pomological characteristics of pear accessions collected from Hatay, Turkey

Accession	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Stalk length (mm)	Stalk thickness (mm)	Average seed number
Baldırıbüyük	160.02	68.27	62.54	42.30	10.26	0.56
Bardak	153.58	64.93	72.02	36.10	5.89	2.93
Dağarmudu 1	28.29	34.11	34.61	25.33	4.06	3.27
Dağarmudu 2	33.89	38.92	34.52	32.23	4.32	4.47
Dermişirin 1	35.19	39.39	33.11	27.44	3.30	8.22
Dermişirin 2	41.24	42.89	37.84	22.63	4.12	4.11
Dermişirin 3	46.09	43.41	36.59	28.50	4.68	3.89
Harman 1	68.89	54.04	56.70	30.29	2.77	6.38
Harman 2	81.97	52.24	54.04	25.03	2.88	3.36
Karbeyaz 1	42.04	43.14	43.18	31.15	6.79	8.00
Karbeyaz 2	34.93	40.27	39.68	34.27	6.07	9.87
Kokarmiski	52.49	45.21	49.51	36.41	2.41	9.73
Kuşboku 1	40.71	40.91	44.41	14.75	4.07	6.77
Kuşboku 2	36.58	40.12	44.69	20.67	3.35	5.90
Kuşboku 3	34.58	38.74	45.49	23.91	3.07	6.53
Şekerpare 1	60.85	48.69	49.84	24.66	6.44	7.20
Şekerpare 2	57.56	48.50	47.18	22.89	8.70	4.13
Şekerpare 3	63.51	49.91	48.51	22.65	8.76	8.00
Tokdemir	45.77	43.57	45.13	31.46	7.81	8.53
Tip 1	31.10	35.56	37.43	29.22	5.97	8.80
Tip 2	47.59	42.08	54.60	22.84	4.36	4.00
Biçin 1	49.06	46.07	46.81	24.10	9.39	9.20
Biçin 2	45.10	45.24	45.50	28.75	9.21	6.67
Biçin 3	42.97	41.82	43.11	35.38	2.13	10.00
Kokulu	69.72	50.21	50.24	28.11	7.31	7.20
Mean	56.15	45.53	46.29	28.04	5.52	6.31
Std	33.15	8.04	9.07	6.43	2.48	2.70

Information with regard to some physical, chemical and nutritional properties of pear are to be more important in both machinery and equipment design for harvesting. Additionally, fruit firmness and skin color is one of the important indicators for both quality, maturity of pears, multiple picking, and post-harvest sorting at the packing house [Kawamura 2000, Abbot and Buta 2002, Ozturk et al. 2010]. The accessions were exhibited variability in terms of flesh firmness, TSS, pH, and acidiy. The flesh firmness was found ‘soft’ for ‘Baldırıbüyük’, ‘Dermişirin 1’, ‘Kuşboku 1’, ‘Kuşboku 2’, ‘Kuşboku 3’, and ‘Tip 2’. The other pear accessions were found ‘intermediate’ (13 accessions), and ‘hard’ (6 accessions). Chauvin et al. [2010] reported that increased fruit firmness resulted in a small amount of juice9 released from the fruit. Soft pear texture is associated with individual cells breaking, the subsequent release of juice and often a juicy pear [Harker et al. 1997]. The highest TSS are showed in semi-soft pears [Dimpy et al. 2011]. The accessions ‘Dağarmudu 2’ (18.80%) and ‘Dağarmudu 1’ (17.60%) with semi-soft had the highest TSS, followed by the accessions ‘Şekerpare 2’

(16.57%). However, some accessions ‘Kokulu’, ‘Tip 2’, ‘Dermişirin 3’ and ‘Harman 1’ had the lower TSS value (tab. 4). Interesting results for total soluble solids were found in the accessions ‘Dermişirin 1’, ‘Dermişirin 2’, and ‘Dermişirin 3’ and ‘Şekerpare 1’, ‘Şekerpare 2’, and ‘Şekerpare 3’, these accessions locally called as same name but grown at different locations. This variability may be due to the genotype, climatic conditions and harvesting dates. It was previously showed that total soluble solids, titrable acidity and pH values of pear fruits which grown in different agro-climatic regions of Turkey were changed between 6–18%; 0.21–0.56% and 3.84–4.52 respectively [Karadeniz [Edizer and Gunes 1997, Guleryuz and Ercisli 1997]. Our findings were consistent with these results.

Table 4. Flesh firmness, total soluble solid (TSS), pH, acidity and fruit skin color characters of local pear accessions sampled from Hatay, Turkey

Accession	Flesh firmness (Libre)	TSS (%)	pH	Acidity (%)	L	a	b	*C*	h^o
Baldırıbüyük	4.15	15.87	4.94	0.15	71.37	-7.17	43.81	44.79	99.40
Bardak	13.23	13.29	4.94	0.1	67.12	-6.72	40.09	41.84	99.08
Dağarmudu 1	7.30	17.60	3.72	0.45	66.25	-11.98	40.58	42.37	106.43
Dağarmudu 2	6.40	18.50	3.57	0.5	71.95	-11.53	41.39	43.00	105.64
Dermişirin 1	3.17	14.80	4.40	0.48	33.98	-3.90	45.10	59.00	49.39
Dermişirin 2	10.30	13.80	4.14	0.22	35.06	-4.00	45.15	60.00	48.42
Dermişirin 3	11.52	11.40	4.00	0.54	36.14	-4.10	45.20	61.00	47.45
Harman 1	7.33	11.93	4.00	0.29	57.42	-6.07	21.45	22.54	78.31
Harman 2	12.21	12.93	3.80	0.24	56.31	-4.97	22.74	23.58	76.66
Karbeyaz 1	7.17	12.50	4.64	0.29	67.59	-12.88	46.42	48.42	105.44
Karbeyaz 2	7.83	14.20	4.28	0.41	66.90	-17.69	45.67	49.03	111.29
Kokarmiski	9.56	13.47	4.19	0.34	73.41	-12.84	52.12	53.79	103.90
Kuşboku 1	4.37	12.12	3.63	0.53	42.31	7.81	36.65	39.38	95.06
Kuşboku 2	3.04	13.90	3.58	0.65	41.06	-6.93	35.48	37.87	93.54
Kuşboku 3	2.99	12.94	3.00	0.62	42.33	-6.16	39.95	42.13	94.65
Şekerpare 1	7.05	12.57	4.36	0.64	69.13	-18.44	47.36	50.90	111.34
Şekerpare 2	7.93	16.57	4.46	0.23	66.75	-15.73	45.40	48.24	109.02
Şekerpare 3	8.44	15.70	4.42	0.29	64.74	-15.46	45.49	48.27	108.57
Tokdemir	7.17	12.30	4.28	0.31	65.51	-15.26	46.54	49.04	108.13
Tip 1	6.68	13.40	4.36	0.27	65.39	-15.79	45.55	48.30	109.20
Tip 2	3.62	11.20	3.57	0.38	71.81	-13.60	48.03	50.19	105.68
Biçin 1	10.44	13.67	4.44	0.87	66.37	-13.98	47.36	49.72	106.11
Biçin 2	6.68	14.13	4.49	0.38	73.48	-12.12	52.14	53.73	103.27
Biçin 3	6.49	12.00	4.38	0.34	62.12	9.95	45.69	46.86	101.89
Kokulu	8.41	10.00	4.29	0.32	64.24	-18.67	41.57	46.11	99.99
Mean	7.84	13.63	4.78	0.39	59.95	-10.42	37.31	39.28	95.12
Std	3.38	2.06	2.08	0.18	12.98	5.81	15.56	16.26	19.55

As shown in Table 4, the fruit skin color L, a*, b*, *C*, and *h*° values of the pear accessions were found to be different. The accessions 'Kokarmiski' and 'Biçin 2' had the lightness fruits with the higher L, b*, C, and *h*° and low a* values than the other accessions. The accessions, generally, had green skin color (negative a* values). Fruit skin color is considered to be the most important index of pear quality and maturity. Previously reported that there were strong relationships between maturity and L, a*, and b* values of pear cultivars and L, a*, and b* values increased with maturation. The b* values of skin color was also found the most important color parameter to correlate sugar increase in pear fruits [Kawamura 2000].

Table 5. Eigen values and cumulative variance of the first five principle component (PC) analysis for the pomological parameters in the local pear accessions

Principal components	PC1	PC2	PC3	PC4	PC5
Eigen value	6.5	4.3	3.6	2.1	1.4
Variance (%)	31.0	20.4	17.0	10.0	7.0
Cumulative Variance (%)	31.0	51.4	68.3	78.4	85.0
Fruit weight	0.11	0.44	0.07	0.12	0.14
Fruit diameter	0.15	0.43	0.04	0.12	0.02
Fruit length	0.21	0.37	-0.03	-0.09	0.15
Stalk length	0.08	0.18	0.22	0.20	-0.15
Stalk thickness	0.21	0.04	0.22	0.27	0.16
Seed number	0.17	-0.32	-0.09	0.00	-0.35
Flesh firmness	-0.09	0.14	0.17	0.14	-0.46
TSS	-0.14	-0.01	0.37	-0.01	0.19
pH	-0.19	-0.03	0.43	-0.13	0.02
Acidity	-0.07	-0.26	-0.15	-0.26	0.39
L	0.23	0.02	0.38	-0.11	0.03
a*	-0.25	0.22	0.15	0.45	0.22
b*	0.12	-0.26	0.15	0.45	0.22
C	-0.01	-0.23	0.03	0.58	0.11
h°	0.26	-0.11	0.28	-0.27	0.21
Ripening time	-0.32	0.25	0.07	-0.43	0.02
Productivity	0.20	-0.08	0.15	-0.15	-0.51
Flavor	0.35	0.06	-0.11	-0.23	0.08
Juiciness	0.23	0.07	-0.38	0.22	-0.05
Grittiness	-0.38	0.05	-0.02	0.04	0.02
Texture	0.34	0.03	-0.15	-0.01	0.08

Principal component analysis was conducted using 21 morpho-pomological variables (tab. 5). Principal components (PC) results indicated that the first five PCAs explained as much as 85.0% of the total variation. The PCA1, PCA2, PCA3, PCA4, and PCA5 explained 31.0, 20.4, 17.0, 10.0, and 7.0% of the total variation, respectively. Scores on the first PCA1 were highly correlated (> 0.35) to characters related to flavor and grittiness. The PCA2 was highly associated with the fruit weight and fruit lenght. The PCA3 was mainly correlated to characters related to the TSS, pH, L, and juiciness.

The stalk thickness, acidity, a*, b*, *C*, and ripening time values were variables of PCA4. The flesh firmness, acidity, and productivity were the most important variables for PCA5. The fruit weight, fruit size (diameter and length), flesh firmness, juiciness and ripening time [Pereira-Lorenzo et al. 2012] were the traits used for the discrimination of local pear accessions. In addition, it can be very useful to use flavor, grittiness, TSS, pH, stalk thickness, and fruit colors (L, a*, b*, *C*) for the identification of pear germplasm.

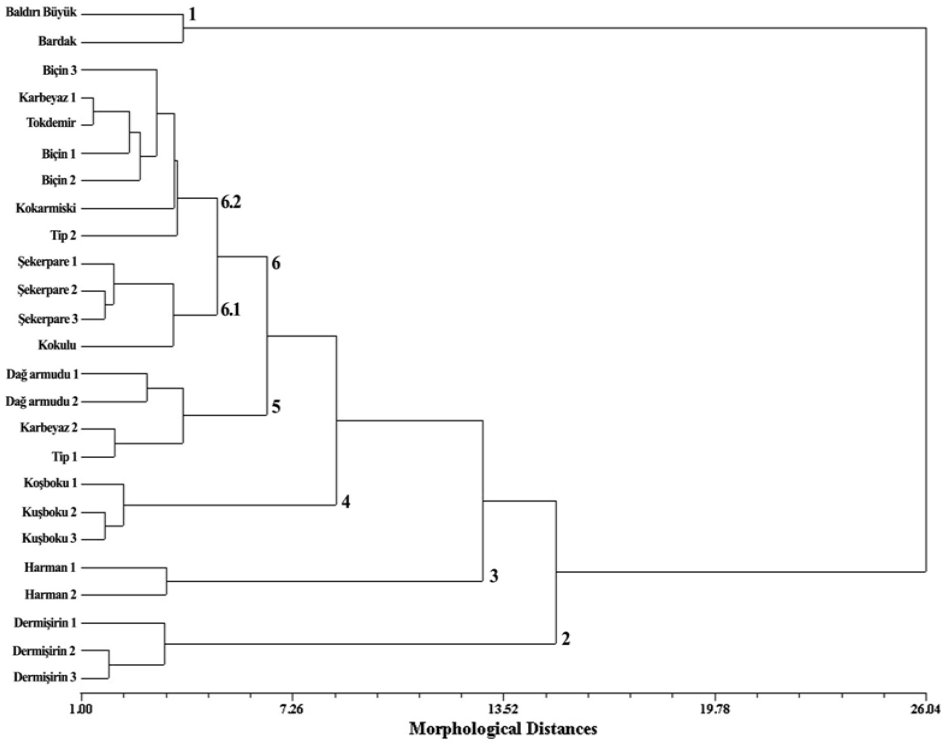

Fig. 1. UPGMA dendrogram based on morpho-pomological distances of local pear accessions sampled from Hatay, Turkey

In the cluster analysis of data combined morpho-pomological properties, the pear accessions were grouped into two clusters (fig. 1). The Group 1 included two pear accessions 'Baldırıbüyük' and 'Bardak'. These accessions were characterized with highest fruit weight and sizes. The rest 23 pear accessions were divided in differ groups. 'Dermişirin 1', 'Dermişirin 2', and 'Dermişirin 3' were in the same Group 2, indicating that these accessions have similar fruit weight and size. Two accessions 'Harman 1' and 'Harman 2' were classified in Group 3. These pear accessions were showed similar characters such as sensory and pomological properties. 'Kuşboku 1','Kuşboku 2', and 'Kuşboku 3' with small fruit sizes and similar acidity, b*, *C*, and h° values were classi-

fied in Group 4. The accessions ‘Dağarmudu 1’ and ‘Dağarmudu 2 and ‘Karbeyaz 2 and ‘Tip 1’ were similar to each other in Group 5. These accessions had small fruit size, higher TSS, and similar b*, *C*, and *h*° values. The Group 6 included 11 accessions, and separated to two subgroups (6.1. and 6.2) which were found to be different morphological characters. The subgroup 6.1 included the accessions of ‘Şekerpare 1’, ‘Şekerpare 2’ ‘Şekerpare 3’, and ‘Kokulu’ with similar to fruit size and skin color. The accessions ‘Karbeyaz 1’ and ‘Tokdemir’ were similar to each other in subgroup 6.2.

The distribution of the accessions based on the PCA1 and PCA2 shows the pomological and sensory variation among the pear accessions and how widely dispersed they are in the circle (fig. 2). The two components explain a cumulative variability of 26.6%. Based on the distribution of accessions, ‘Baldırıbüyük’ (1) and ‘Bardak’ (2) were the most closely related to that Group A while the Group B was showed the accessions ‘Dermişirin 1’ (6), ‘Dermişirn 2’ (7), and ‘Dermişirin 3’ (8) to be the least similar to the rest groups of the accessions ‘Harman 1’ (9) and ‘Harman’ 2 (10) that were classified in Group C. Group D was included ‘Kuşboku 1’ (14), ‘Kuşboku 2’ (15) and ‘Kuşboku 3’ (16). The rest accessions were classified in Group E.

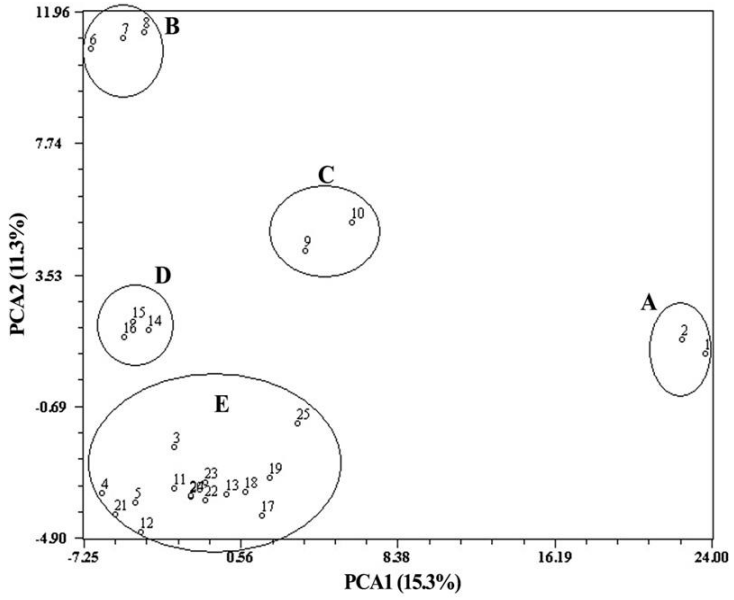

Fig. 2. Principal components analysis grouping of 25 pear accessions based on morpho--pomological properties

The PCA results showed that there were great variations among 25 accessions depended on morpho-pomological characters. The accessions ‘Biçin’ (3 accessions), ‘Dağarmudu’ (2 accessions), ‘Dermişirin’ (3 accessions), ‘Harman’ (2 accessions), ‘Kuşboku’ (3 accessions), and ‘Şekerpare’ (3 accessions) were separated differ group

and subgroup, but the accessions with same name were similar group. Therefore, these accessions may be similar genetic origine. 'Baldırıbüyük' and 'Bardak' and 'Karbeyaz 1' and 'Tokdemir' had similar morphological charachters. These accessions may be synonymous (accessions with the same genetic profile but a different traditional name). These results showed that such clustering is observed due to presence of synonymous, homonymous, and the similar accessions in Hatay. It is possible that the same name would be used to genetically different pear accessions with similar morpho-pomological and chemical traits among local areas.

For the identification of fruit genetic resources, the morpho-mological properties of the genotypes are extremely important. However, these traits are affected by ecological conditions and cultural practices. Considering the environmental influence, it was possible to conclude that in order to gain information concerning the genetic variability for conservation perspectives, molecular markers were preferred with respect to morphological markers. Globally, a high genetic variability in the local apple and pear genetic resources was defined by SSR markers, which at the same time were successfully applied in solving the problem of synonymous and erroneous denominations [Martinelli et al. 2008]. This instrument will be essential in order to determine homonymy and synonymy and make possible to study phylogenetic relationships, and the extent of genetic variability of the local accessions belonging to different areas in Turkey and other countries.

Results from this study will help to determine curatorial decisions regarding issues such as de-accessioning in the *ex situ Pyrus* germplasm collection existing from Hatay, in eastern Mediterranean region of Turkey and guide endeavors to establish *in situ* germplasm reserves for these typical fruits production which preserve maximal amounts of genetic diversity for the species.

CONCLUSIONS

Morpho-pomological properties of local pear accessions showed a great diversity. The accessions were considerable due to their high quality characteristics. 'Baldırıbüyük', 'Bardak', 'Harman 1', 'Harman 2', and 'Kokulu' accessions were very promising for fresh consumption based on fruit quality characters. 'Biçin 1', 'Biçin 2', 'Karbeyaz 1', 'Karbeyaz 2', 'Kokarmiski', 'Şekerpare 1', 'Şekerpare 2', 'Şekerpare 3', 'Tokdemir', 'Tip 1', and 'Kokulu' accessions can be used for early season pear breeding. In addition 'Kokulu' accession has a nice aromatic smell, and this feature should be evaluated for breeding studies.

Our results indicated that fruit properties and chemical parameters were the highest discriminator among the pear accessions. However, pomological and chemical characters are affected by environment conditions and can not be distinguished among similar accessions. Therefore, molecular markers are used to together with the morphological and pomological parameters for the identification of genotypes.

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MORFOLOGICZNA I POMOLOGICZNA RÓŻNORODNOŚĆ TURECKICH ODMIAN GRUSZY (*Pyrus communis* L.) WE WSCHODNIM ŚRÓDZIEMNOMORSKIM REJONIE TURCJI

Streszczenie. Ochrona i zrównoważone użycie genetycznych zasobów roślin są ważne, ponieważ zagwarantują bezpieczeństwo żywności w przyszłości. Niniejsze badanie przeprowadzono na dwudziestu pięciu odmianach z Hatay, prowincji we wschodnim śródziemnomorskim rejonie Turcji. Określono czas dojrzewania, wydajność oraz pewne ważne cechy pomologiczne, takie jak masę owoców, rozmiar owoców, całkowitą zawartość rozpuszczalnych związków stałych, pH oraz kwasowość. Zmierzono także chropowatość, zapach i soczystość w ramach analizy sensorycznej. Najwcześniej dojrzewały ‘Biçin 1’ i ‘Biçin 2’ (25 czerwca w 2009 i 23 czerwca w 2010), natomiast najpóźniej ‘Dağarmudu 1’ i ‘Dağarmudu 2’ (8 listopada w 2009 i 5 listopada w 2010). Wydajność określono jako średnią i wysoką. Masa owoców wahała się między 28,29 a 160,02 g, liczba nasion między 0,56 a 10,00, zawartość rozpuszczalnych związków stałych między 10,00 a 18,50%. U odmian gruszy, 15 zamiast wszystkich 21 cech morfo-pomologicznych owoców może wyjaśnić 85% całkowitej zmienności. W rezultacie, niektóre odmiany gruszy mogą być rekomendowane do hodowli i do badań hodowlanych w kategoriach wczesności i aromatu.

Słowa kluczowe: *Pyrus communis*, czas dojrzewania, plon, cechy owoców, barwa owoców

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