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PHYSICAL, CHEMICAL, SENSORIAL AND BIOACTIVE CHARACTERISTICS OF LOCAL AND STANDARD PEAR CULTIVARS IN TURKEY

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Abstract. Some important physical (fruit external color, flesh firmness, fruit size, fruit weight, fruit volume, stone cell), chemical (ash, pH, soluble solid content, sugars, titratable acidity), sensorial (appearance, firmness, sweetness, grittiness, juiciness and overall quality) and bioactive (antioxidant capacity, phenolic compounds, total phenolic content, vitamin C) characteristics of eleven local and one standard pear cultivar were investigated. All cultivars were found in national pear repository in Ataturk Horticultural Central Research Institute in Turkey. Fruit weight of pears was between 56.80 g ('Kirmizi Biber') and 128.94 g ('Erkenci Uzun Sap'). Results showed that 'Bağ' cultivar had the highest sensorial scores (8.4 overall quality) and antioxidant capacity (21.44 mg ascorbic acid equivalent·g^{-1}). Stone cell were found between 63.65 ('Gümüşhane') and 81.65 mg dry weight·g^{-1} ('Maslovka'). The cultivar 'Orak' showed the highest chlorogenic acid (185.98 mg·kg^{-1}) and epicatechin (108.26 mg·kg^{-1}) content.

Key words: pear, phytochemicals, stone cell, bioactive content

INTRODUCTION

Horticulture concerned with plants that are used by people for food, either as edible products, or for culinary ingredients, for medicinal use or ornamental and aesthetic purposes. They are genetically very diverse group and play a major role in modern soci-

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ety end economy. Fruits and vegetables are an important component of traditional food, but are also central to healthy diets of modern urban population [Bajpai et al. 2014, Feng et al. 2014, Ruttanapraset et al. 2014, Mlcek et al. 2015].

Even though China's pear production sharply rises over the last decade that has caused a rapid increase in world pear production, there has been a stable production trend for pears in Southern Europe and Oceania and decreasing production trend in Eastern and Central Europe [FAO 2005, 2010, 2013]. However interest to pear cultivation in Turkey has been showing increment in each year.

Physical properties of pear are significant not only for morphological classification both also in machinery and equipment designs for both harvesting and post-harvesting technologies including transporting, sorting, cleaning, sizing, packaging etc. and also processing pear into different foods [Kawamura 2000, Deckers and Schoofs 2008].

Fruit firmness and skin color of pears are one of the most crucial signs for both quality and maturity determination [Kawamura 2000, Ozturk et al. 2009]. Also, volume and density properties of pear fruits are important for various technological processes and product quality evaluation [Dar et al. 2012]. Soluble solid content is very important for quality assessment and determine maturity as well [Ozturk et al. 2009]. Bioactive content including vitamin C, phenolic profile and antioxidant capacity of pear fruits has gained more importance recently both among consumers and breeders [Proteggente et al. 2002, Galvis-Sanchez et al. 2003].

New pear cultivars, which contain combination of decent taste quality for fresh consumption and enough capacity for industrial processing, are strongly required [Deckers and Schoofs 2008, Akçay et al. 2014]. The right cultivar choice is important for establishing new pear orchard [Kappel et al. 1995].

More recently there is an increasing interest to local fruit cultivars throughout the world including pear [Alizadeh et al. 2015], mango [Shirin et al. 2013, Veda et al. 2007], banana [Adeniji et al. 2007] and papaya [Veda et al. 2007] and these researchers stated that several local fruit cultivars have potential to be registered as a new cultivar for new plantations with good commercial opportunities when introduced to producers and food processors properly [Veda et al. 2007, Alizadeh et al. 2015, Adeniji et al. 2007]. As Turkey very rich in terms of local fruit cultivars in particular for temperate fruits, we aimed to investigate the physicochemical, nutritional and sensorial characteristics of local pear cultivars and compare these results with standard 'Maslovka' cultivar. Another significant objective was establishing convenient reference tables with the gathered data, which can also be used as a guide for cultivar selection, building orchards or production, processing and marketing of pear.

MATERIAL AND METHOD

Plant material. Eleven local pear cultivars and standard 'Maslovka' cultivar (originated in Czech Republic) were used as material that found in a single gene bank orchards of Ataturk Horticultural Central Research Institute Yalova, Turkey. Local pear cultivars are collected from different parts of Turkey and brought to Institute before. In order to achieve average proper sized pears, pears were harvested on the commercial harvest date between September–October of 2009, 2010 and 2011. A total 30 fruits harvested from each cultivar and used for measurement and analysis.

Physicochemical analysis. Physical measurements were made on fruit weight, volume, length, diameter, and stalk length of the fruits. Color of samples was determined by using The Minolta CR-400 model chroma meter (Konica Minolta, Japan). After removing the peel, Effegi type (Bishop FT327 Poland) firmness tester with a 7 mm plunger was used on 3 sides of each fruit in order to determine flesh firmness and results were given as kilogram [Blankenship et al. 1997]. Refractometer (Atago, Japan) was used for measuring soluble solids content. Ash content was determined by incineration at 550ºC in a muffle furnace, throughout 8–10 hours [Sáenz et al. 1998]. Fruits were homogenized and total titratable acidity (as malic acid equivalent) was determined by titration with 0.1 N NaOH solution until pH reached 8.1 [Naor 2001]. Each fruit was peeled, separated to core and diced for stone cell analysis. 20 g pear flesh sample was homogenized with distilled water in waring blender for 5 min. The homogenate was diluted with water containing 0.1 M NaCl solution. The suspension was incubated for 30 min at 20–22°C and the supernatant phase decanted. The sediment was incubated for 30 min with 0.5 L of 0.5 N NaOH solution and decanted afterwards. Finally, the sediment was suspended in 0.5 L of 0.5 N HCl solution for 30 min. Later it was decanted and washed with water. Washing operations mentioned above were repeated several times until the stone cells had been set free of extraneous cell debris [Ranadive and Haard 1973].

Ascorbic acid analysis. Ascorbic acid content was determined with the indophenol method by titrating of 4 g sample with 2,6-dichlorophenol indo phenol dye using metaphosphoric acid (3%) as an extracting media according to Favell [1998].

Total phenolic content. Folin-Ciocalteu method was used to determine total phenolic content [Singleton and Rossi 1965]. 5 g homogenized pulp sample was extracted with methanol 3 times. 0.5 ml aliquot from methanolic extract and 1 ml from 0.5 M Folin-Ciocalteu reagent were taken. Later, they were mixed in a test tube. The mixture was kept still for 5 min, afterwards 3 ml of Na_2CO_3 (20%) solution was added and solution was completed to 10 ml by using distilled water. After stirring solution, it was left to stand for 30 min at room temperature. Later, mixture was centrifuged at 3500 rpm for 10 min and the absorbance of the supernatant was read at 725 nm by using a spectrophotometer (Shimadzu UV-2900, Japan). Total phenolic content of the sample was expressed as gallic acid equivalents.

Total antioxidant capacity. Method described by Dasgupta and De [2004] was used to determine total antioxidant capacity. 0.3 ml aqueous extract and 3 ml of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) were mixed in a test tube. Water bath was applied to tubes at 95°C for 90 min. After, the mixture was cooled at room temperature and the absorbance of the solution was measured against a blank (3 ml reagent solution with 0.3 ml distilled water) at 695 nm. Antioxidant capacity of the sample was expressed as ascorbic acid equivalent.

Phenolic compounds. 200 mg freeze-dried pear flesh was homogenized in 5 ml 100% methanol and then it was centrifuged in 18 g tubes for 20 min. Methanol phase of the supernatant was evaporated by using rotary evaporator. Dissolving the resultant residue in 160 µl methanol followed by applying 840 µl phosphate buffer (0.1 M), filtering (0.45 µm) and collecting into an auto-sampler vial for HPLC analysis. Chlorogenic acid, epicatechin, catechin, rutin and gallic acid amounts were measured by using Adsorbo Sphere Cle 3 µm HPLC column (150 mm × 4.6 mm) with diode-array detector. Solvents used in the system were a gradient of A (water, pH 2.6 made with H_3PO_4) and B (acetonitrile–MeOH–water 1:3:1). The following proportions were applied for gradient: 0 min, 5% B; 0–5 min, 12% B; 5–10 min, 12% B isocratic; 10–44 min, 50% B; 44–70 min, 50% B isocratic. The solvent flow rate was set to 0.8 mL/min and the separation was observed at 35°C [Gorsel et al. 1992, Amiot et al. 1995].

Sensorial evaluation. A total 20 people, who were either food or agriculture engineers and also had experience on sensorial evaluation of fruits, were participated to sensorial analysis. Pears from varied cultivars were presented simultaneously on separately coded plates; the samples had been cut into quarters and peeled just before evaluation. Some qualities of fruits such as appearance, firmness, sweetness, grittiness, and juiciness were evaluated as well as overall quality. A hedonic test was applied for sensorial evaluation. Panelists were asked to evaluate appearance, firmness, sweetness, juiciness and overall quality by using 9-point hedonic scale. Degree of liking was 1 = dislike extremely, 3 = dislike moderately, 5 = limit of acceptability, 7 = like moderately, 9 = like extremely [Stevens and Albright 1980, Kappel et al. 1995].

Statistical analysis. Study plan was performed according to the randomized experimental design. 10 replicates were used for color measurement tests whereas 3 replicates were used for other analysis. All of the analyze results were calculated in terms of mean and standard error of mean for average of 3 years (2009, 2010 and 2011). Analysis of variance was made by applying Duncan multiple comparison test of the means ($p < 0.05$) in order to determine existing significant differences among the samples. Statistical analysis was performed with software known as JMP v. 5.0 statistical package program (SAS Institute, Cary, N.C., U.S.A.).

RESULTS AND DISCUSSION

Some important fruit characteristics of pear cultivars studied are summarized in Table 1.

More recently, interest in production of pear cultivars has raised and in particular information available concerning their physicochemical, nutritional and sensory characteristics [Bai et al. 2009, Rezaeirad et al. 2013, Alizadeh et al. 2015].

In this study, measurements corresponding to fruit stalk length, vertical length and diameter were determined as 1.15 cm ('Gümüşhane') – 4.95 cm ('Bal'), 3.6 cm ('Kirmizi Biber') – 5.9 cm ('Maslovka') and 3.5 ('Kirmizi Biber') – 7.1 cm ('Cin') respectively (tab. 1). Pear fruit diameters were reported between 4 cm and 8 cm in the literature previously [Sawaya et al. 1983, Garriz et al 2005, Lepaja et al. 2013]. The average diameters of 'Spadona' and 'Coscia' pear cultivars were determined as 5.5 cm and

5.0 cm respectively [Stern and Flaishman 2003]. When compare to our study, some of the cultivars have greater diameter than 'Spadona' and 'Coscia' cultivars whereas some of them have similar diameter. According to Kappel et al. [1995] optimum fruit diameter of pears should be between 6 cm and 7.5 cm.

Fruit shape in pears is a polygenic characteristic [White et al. 2000], which is determined by height and width parameters. *Pyrus* fruits more often prone to be round than pyriform shape in both Asian, European and interspecific pear populations [White and Alspach 1996]. Ideal pyriform shape ratio as length to diameter ranges from 1.44 to 1.48 and very round or elongated fruits are stated as unfavorable [Kappel et al. 1995]. Cultivars whose origin is in Asia range varies to be pyriform to the slightly oblate, despite most of them tend to be ovate [White et al. 2000]. In this research length to diameter ratio of pears were observed between 0.68 and 1.14, which are lower compared to specified values by Kappel et al. [1995].

In this research, fruit weight values of pears were between 56.80 g ('Kirmizi Biber') and 138.94 g ('Erkenci Uzun Sap') while volume values differed from 50.3 ml ('Kirmizi Biber') to 120.0 ml ('Erkenci Uzun Sap'). These local pear cultivars are classified as small and medium sized. In literature previously pear fruit weights were measured between 144 g and 240 g by Pimienta-Barrios [1994] and 150 g and 250 g by Kappel et al. [1995]. Average fruit weight and volume of 'Küçük Kışlık Armut' was reported as 89.73 g and 85.05 ml by Yarilgaç and Yildiz [2001]. Since consumers prefer large pears [Flaishman et al. 2001, Stern et al. 2002], fruit weight becomes extremely important factor for both marketing and economic benefits [Flaishman et al. 2001].

Table 1. Fruit stalk length, dimensions (length, diameter), length/diameter ratio, fruit weight and volume of studied cultivars (average of 2009–2011 years)

Cultivars	Fruit stalk length (cm)	Fruit length (cm)	Fruit diameter (cm)	Length/ diameter ratio	Fruit weight (g)	Fruit volume (ml)
İğnesi	3.25 ±0.12c	4.9 ±0.07d	4.3 ±0.12f	1.14	78.79 ±0.15g	80.3 ±1.4e
Gümüşhane	1.15 ±0.10h	5.6 ±0.11b	5.3 ±0.13c	1.06	112.04 ±0.16c	106.2 ±2.0b
Bal	4.95 ±0.16a	4.7 ±0.08d	4.8 ±0.11e	0.98	83.57 ±0.17f	68.6 ±1.2f
Erkenci Buzbağ	3.05 ±0.11d	5.2 ±0.10c	5.0 ±0.14d	1.04	95.49 ±0.14e	93.2 ±1.3d
Cennet	4.75 ±0.16a	3.8 ±0.10f	4.0 ±0.11g	0.95	63.47 ±0.16i	56.5 ±1.0g
Erkenci UzunSap	4.55 ±0.14b	5.6 ±0.13b	6.2 ±0.12b	0.90	138.94 ±0.17a	130.0 ±2.0a
Kırmızı Biber	2.10 ±0.11f	3.6 ±0.12f	3.5 ±0.11h	1.03	56.80 ±0.13k	50.3 ±1.7h
Bağ	2.35 ±0.15f	4.7 ±0.11d	6.1 ±0.13b	0.77	96.85 ±0.16e	89.2 ±1.5c
Orak	1.75 ±0.12g	4.4 ±0.12e	4.3 ±0.09f	1.02	63.83 ±0.11h	57.5 ±1.3e
Cin	1.70 ±0.11g	4.8 ±0.10d	7.1 ±0.12a	0.68	100.91 ±0.14d	97.1 ±2.0b
Alyanak	2.50 ±0.14e	3.7 ±0.08f	5.2 ±0.11d	0.71	61.28 ±0.15i	60.6 ±15f
Maslovka	3.15 ±0.13c	5.9 ±0.09a	5.5 ±0.12c	1.07	120.14 ±0.18b	107.7 ±1,0h

Different letters in the same column refers to statistical difference ($p < 0.05$)

Fruit color is another key characteristic which gives an idea to consumers about quality and maturity of fruit [Ozturk et al. 2009, Zhang et al. 2011]. Color readings (as L, a and b values) of pear skin and flesh are demonstrated in Table 2. There were statistically important differences among cultivars in terms of L, a and b values ($p < 0.05$). The highest L, a and b value were obtained from 'Cin', 'Maslovka' and 'Alyanak' as

74.46, 15.60 and 42.59, respectively (tab. 2). Ozturk et al. [2009] reported L and b value for cultivar Santa Maria as 75.68% and 44.06 and they found that Santa Maria cultivar had higher L and a value than cv. Deveci. 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].

Skin color of pears differed in a wide range, but the most acceptable one is yellow. Bright yellow skin color for pears is considered as ideal whereas green or red skin was rated less favorable [Ozturk et al. 2009]. On the other hand, red skin fulfills aesthetic lookout of consumers; therefore, red skinned pears were widely distributed throughout China in a short time [Tao et al. 2004, Huang et al 2009]. 'Bal', 'İğnesi', 'Cin' and 'Alyanak' pears had yellow skin color and 'Maslovka', 'Erkenci Buzbağ' and 'Erkenci Uzun Sap' had yellowish-red skin color. These fruits were desirable according to both Kappel et al [1995] and Huang et al [2009].

Table 2. Skin color values of pear cultivars (average of 2009–2011 years)

Cultivars	Skin color		
	L	a	b
İğnesi	55.36 ±2.21e	5.64 ±0.22d	39.13 ±1.15b
Gümüşhane	47.33 ±1.66g	4.17 ±0.11e	26.40 ±0.99e
Bal	58.91 ±1.81d	2.36 ±0.18f	39.29 ±1.09b
Erkenci Buzbağ	44.72 ±1.55h	11.57 ±0.15b	32.04 ±1.14c
Cennet	62.12 ±2.21c	8.78 ±0.12c	37.65 ±0.98b
Erkenci UzunSap	53.00 ±2.14f	10.64 ±0.14b	33.16 ±1.08
Kırmızı Biber	45.89 ±1.65g	6.72 ±0.16d	22.8 ±1.12f
Bağ	65.86 ±1.89b	7.14 ±0.20c	31.99 ±1.14c
Orak	59.25 ±1.60d	3.98 ±0.11e	28.81 ±1.10d
Cin	74.46 ±2.10a	4.26 ±0.17e	30.40 ±0.99d
Alyanak	73.79 ±2.15a	3.57 ±0.14e	42.59 ±1.12a
Maslovka	52.76 ±1.67f	15.60 ±0.16a	32.02 ±1.10c

Different letters in the same column refers to statistical difference ($p < 0.05$)

Another two considerable quality attributes of pears are soluble solids content and especially firmness [Verlindena et al. 2008, Huang et al. 2009]. Flesh firmness and titratable acidity values of pears are presented in Table 3. Those values were found between 128.2 g ('Bal') – 1243.5 g ('Kirmizi Biber') and 0.06% ('Erkenci Buzbağ') – 0.38 ('Erkenci Uzun Sap'), respectively (tab. 3). Soluble solid, ash and stone cell content of pears are given in Table 3. In this study, soluble solids, ash and stone cell contents were detected between 7.43–11.14 brix, 0.22–1.02% and 62.13–81.65 mg dry weight·g^{-1} respectively. Pears can be preferred firm and crisp or soft and smooth depending on customers [Verlindena et al. 2008, Dewulfa et al. 1999]. The soluble solid content and firmness of pears were determined between 10.4–15.4% and 9.9–110.7 N by Verlindena et al [2008]; moreover, ideal pears possess firmness of 18–22 N, greater soluble solid content than 14% with titratable acidity 0.18 mg malic acid per 100 ml juice according to Kappel et al. [1995]. Sawaya et al. [1983] determined the acidity of the pear flesh as citric acid, which was 0.18%. Yarilgaç and Yildiz [2001] reported titratable acidity of some pear varieties between 0.240–2.451%.

Table 3. Flesh firmness, SSC, titratable acidity, ash and stone cell content of pear fruits (average of 2009–2011 years)

Cultivars	Flesh firmness (g)	Titratable acidity (%)	SSC (Brix°)	Ash (%)	Stone cell (mg dry weight·g^{-1})
İğnesi	207 ±5.2i	0.16 ±0.05c	7.43 ±0.75c	0.64 ±0.12c	76.82 ±4.20b
Gümüşhane	996 ±11.2c	0.09 ±0.03d	9.16 ±0.52b	0.62 ±0.11c	63.65 ±8.12e
Bal	128 ±4.8k	0.26 ±0.04bc	8.33 ±0.64c	0.60 ±0.11c	70.10 ±3.75d
Erkenci Buzbağ	626 ±8.3e	0.06 ±0.02d	9.49 ±0.85b	0.57 ±0.13d	75.42 ±6.20b
Cennet	145 ±7.5k	0.23 ±0.02b	10.01 ±0.66a	1.02 ±0.14a	68.93 ±5.25d
Erkenci UzunSap	429 ±10.0gh	0.30 ±0.04ab	9.16 ±0.58b	0.43 ±0.12e	72.52 ±8.12c
Kırmızı Biber	1243 ±12.8a	0.38 ±0.03a	8.14 ±0.76c	0.90 ±0.10ab	77.31 ±9.10b
Bağ	308 ±7.5h	0.07 ±0.02e	8.90 ±0.82b	0.26 ±0.11c	68.87 ±5.62d
Orak	1062 ±11.6b	0.08 ±0.02e	8.15 ±0.80c	0.27 ±0.09f	62.13 ±5.20e
Cin	944 ±9.7dc	0.11 ±0.03de	9.67 ±0.75b	0.22 ±0.12f	73.02 ±7.36c
Alyanak	573 ±13.1f	0.12 ±0.04d	10.07 ±0.56a	0.40 ±0.11c	76.72 ±5.60b
Maslovka	488 ±6.1g	0.19 ±0.05c	11.14 ±0.80a	0.82 ±0.11	81.65 ±4.32a

Different letters in the same column refers to statistical difference ($p < 0.05$)

Table 4. Vitamin C, total phenolic content and antioxidant capacity in pear cultivars (average of 2009–2011 years)

Cultivars	Vitamin C (mg·kg^{-1})	Total phenolic content (mg gallic acid·kg^{-1})	Antioxidant capacity (mg ascorbic acid equivalent·g^{-1})
İğnesi	38.81 ±0.26c	413 ±3.56d	11.15 ±0.90e
Gümüşhane	29.48 ±0.24g	389 ±4.52e	20.32 ±1.08a
Bal	32.94 ±0.35f	370 ±4.26f	18.67 ±1.20b
Erkenci Buzbağ	38.57 ±0.20c	307 ±2.35i	13.53 ±1.15d
Cennet	42.38 ±0.22b	450 ±3.58bc	14.49 ±0.90d
Erkenci UzunSap	45.04 ±0.30a	465 ±7.36ab	17.64 ±2.10c
Kırmızı Biber	29.07 ±0.24g	335 ±6.23g	11.48 ±0.85e
Bağ	20.19 ±0.30ı	319 ±5.36h	21.44 ±0.90a
Orak	36.21 ±0.22d	470 ±4.53a	14.46 ±1.10d
Cin	34.60 ±0.20e	368 ±6.24f	9.81 ±1.12f
Alyanak	26.49 ±0.28h	338 ±6.54fg	16.49 ±1.16c
Maslovka	26.56 ±0.20h	416 ±6.85d	19.19 ±1.20b

Different letters in the same column refers to statistical difference ($p < 0.05$)

Our flesh firmness and titratable acidity results was similar compared to results of Yarilgaç and Yildiz [2001] and Sawaya et al. [2001]. Kappel et al [1995] reported soluble solid content of pear fruits between 13.6–17.2%. Furthermore, soluble solid content of some pear varieties were reported between 9.80–17.00% by Yarilgaç and Yildiz [2001]. The ash content of 'Akça', 'Ankara', 'Passe Crassane', 'Santa Maria', 'Starkrimson', 'Şeker' and 'Williams' pear varieties was found between 1.94–4.81 g·kg^{-1}

by Karadeniz [1999] in juice form. Also, ash content of 'Ankara' pear was reported as 1.0% [Özaydın and Özçelik 2014]. While fruit size increases throughout maturity the relative decrease in fresh weight in stone cell content might have been caused by increases in water, sugars, and other organic compounds [Lee et al. 2006]. Most of the pear varieties contain stone cells, which impart a gritty texture. According to research of Lee et al. [2006] stone cells in pear flesh contained 22.6 mg to 117.4 mg dry weight·g^{-1}. In this research dry weight content of stone cells were between 63.6–81.6 mg dry weight·g^{-1} (tab. 3). Lee et al. [2006] reported that stone cell formation in pear fruits occur at initial stage of growth and may keep on actively.

Vitamin C, total phenolic content and antioxidant capacity of fruits of cultivars are indicated in Table 4. There were significant differences among cultivars for all those 3 parameters. Vitamin C, total phenolic content and antioxidant capacity were found between 20.19 ('Bağ')–45.04 mg·kg^{-1} ('Erkenci Uzun Sap'), 307 ('Erkenci Buzbağ')–470 mg gallic acid equivalent·kg^{-1} ('Orak') and 9.81 ('Cin')–21.44 mg ascorbic acid equivalent·g^{-1} ('Bağ'), respectively (tab. 4). Sawaya et al. [1983] determined vitamin C in pear fruits as 22.1 mg·kg^{-1}.

Total polyphenol amount in pear was determined between 196–457 mg·l^{-1} by Tanrioven and Eksi [2005] and 326–473 mg·kg^{-1} by Karadeniz et al. [2005]. Karadeniz et al. [2005] reported antioxidant activity of pear fruit as 11.5 to 16.7% ascorbic acid equivalent. Antioxidant activity and total phenolic content in fruits showed a strong connection indicating that phenolic compounds are the main contributor to antioxidant activity of pear fruits which is also parallel to studies of Galvis-Sanchez et al. [2003], Karadeniz et al. [2005] and Burns et al. [2000]. Studied fruits showed similar ascorbic acid contents to studies by Sawaya et al [1983] and Karadeniz [1999].

Phenolic compounds in pear fleshes were presented in Table 5. Chlorogenic acid was found between 115.94–185.98 mg·kg^{-1} among cultivars, which was higher than any other phenolic compounds (tab. 5). Major phenolic compounds of pear is phenolic acids; arbutin, catechins, flavonols and procyanidins in particular [Oleszek et al. 1994].

Table 5. Phenolic compounds in pear fleshes (mg·kg^{-1}) (average of 2009–2011 years)

Cultivars	Chlorogenic acid	Epicatechin	Catechin	Rutin	Gallic acid
İğnesi	159.55 ±1.68c	95.11 ±3.26b	45.49 ±1.63b	43.62 ±1.62b	21.95 ±2.32c
Gümüşhane	132.12 ±2.32e	89.50 ±2.97c	42.80 ±1.16c	46.69 ±1.02ab	27.24 ±1.77b
Bal	141.97 ±2.02d	85.25 ±1.68c	40.77 ±1.68c	30.48 ±2.38d	35.07 ±0.78a
Erkenci Buzbağ	115.94 ±1.68g	70.65 ±0.35e	33.79 ±1.32f	33.86 ±1.46c	20.50 ±0.86cd
Cennet	174.53 ±3.30b	103.52 ±0.48	49.51 ±0.95a	54.01 ±1.68a	23.50 ±1.11c
Erkenci UzunSap	181.00 ±3.07a	107.15 ±2.35a	51.24 ±1.77a	51.90 ±1.81a	32.61 ±1.30a
Kırmızı Biber	127.74 ±1.68ef	77.27 ±0.63d	36.95 ±1.42d	37.31 ±1.23c	13.52 ±1.14e
Bağ	121.87 ±2.56f	73.41 ±1.30de	35.11 ±0.76d	38.30 ±1.48c	22.34 ±1.02c
Orak	185.98 ±2.56a	108.26 ±1.77a	46.77 ±2.00b	43.48 ±1.34b	18.95 ±1.30d
Cin	141.11 ±2.03d	84.77 ±1.64c	40.54 ±2.32c	32.23 ±1.17c	35.80 ±1.32a
Alyanak	118.65 ±2.52fg	77.78 ±2.56d	37.20 ±1.95d	30.58 ±1.02d	20.67 ±0.92d
Maslovka	160.60 ±1.77c	95.70 ±3.81b	45.77 ±0.85b	49.93 ±1.05a	26.13 ±1.30b

Different letters in the same column refers to statistical difference ($p < 0.05$)

Catechin, epicatechin, chlorogenic acid, quercitrin and quercetin were reported as main phenolic compounds of pear [Spanos et al. 1990, Tanrıoven and Eksi 2005]. Cui et al [2005] reported the chlorogenic acid contents of the 'Oriental' and 'Occidental' pear cultivars as 163 mg·kg^{-1} and 309 mg·kg^{-1}. Gallic acid, catechin, chlorogenic acid, caffeic acid, epicatechin and rutin amounts were determined between 5.23–10.72, 0.41–28.83, 485.11–837.03, 0–1.16, 6.73–131.49, 0.92–104.64 µg·g^{-1} respectively by Li et al [2001]. In this research, measurements of main phenolic compounds in pear sample showed similarities with the study of Oleszek et al. [1994], Cui et al. [2005] and Li et al. [2011] but it differed from the study of Ferreira et al. [2002].

Sensorial evaluation of fruit characteristics in terms of appearance, firmness, sweetness, grittiness, juiciness, overall quality of pears were given in Table 6.

Table 6. Sensorial evaluation of pear fruits (average of 2009–2011 years)

Cultivars	Appearance	Firmness	Sweetness	Grittiness	Juiciness	Overall quality
İğnesi	8.3 ±2.0a	6.2 ±0.7d	6.8 ±0.8c	5.2 ±0.6d	7.1 ±0.6ab	8.1 ±1.0a
Gümüşhane	5.8 ±0.6e	7.7 ±0.8b	6.9 ±0.5c	8.0 ±1.2a	7.9 ±1.2a	7.2 ±0.5b
Bal	8.0 ±2.0a	6.6 ±0.8d	7.4 ±0.9b	7.2 ±1.5b	6.2 ±0.7c	7.9 ±1.0a
Erkenci Buzbağ	7.2 ±1.2c	8.4 ±0.6a	7.7 ±1.1b	6.1 ±0.6c	8.2 ±2.0a	7.7 ±1.3b
Cennet	8.1 ±2.0a	5.3 ±0.5e	8.2 ±1.5a	7.5 ±0.7ab	5.3 ±0.6cd	6.9 ±0.5bc
Erkenci UzunSap	6.8 ±0.5c	7.0 ±0.6c	7.3 ±0.7b	6.5 ±0.7b	7.8 ±1.0a	7.4 ±0.8b
Kırmızı Biber	6.5 ±1.0cd	4.5 ±0.5f	6.7 ±0.8c	6.9 ±0.8b	4.5 ±0.5d	5.6 ±0.6c
Bağ	7.9 ±2.0b	8.2 ±2.0a	8.5 ±2.0a	7.3 ±0.6ab	8.2 ±1.2a	8.4 ±1.2a
Orak	6.4 ±1.5d	6.6 ±0.8d	7.3 ±0.7b	7.8 ±0.7a	6.6 ±0.8c	6.2 ±0.5c
Cin	8.2 ±1.2a	7.1 ±1.5bc	6.8 ±0.8c	6.3 ±0.8c	7.1 ±1.1ab	7.8 ±1.1a
Alyanak	8.5 ±1.5a	7.8 ±1.2b	6.1 ±0.7d	6.6 ±0.6b	7.8 ±1.5a	8.0 ±2.0a
Maslovka	7.7 ±0.8b	7.6 ±0.7b	6.9 ±0.8c	5.5 ±0.5d	7.6 ±1.1ab	7.5 ±1.1b

Different letters in the same column refers to statistical difference ($p < 0.05$)

Pear is a widespread fruit, which consumers eagerly use as fresh product [Krasnova et al. 2011]. In the marketplace, consumers generally pay attention to size and color of pear as well as its taste and substantially accessibility which in its turn has affect on the chemical composition of pears [Błaszczyk et al. 2010, Krasnova et al. 2011]. Sensory characteristics are prior for evulation and selection of new pear cultivars [Kappel et al. 1995, Błaszczyk et al. 2010]. Results of sensory evaluation for grittiness and sweetness in pear fruits were reported as 1 samples high, 3 samples as middle, 10 samples as scarce and 1 sample as zero by Yarilgaç and Yildiz [2001]. Reported sweetness and hardness values of pear fruits differ between 6–10 and 1–3 respectively according to Huang and Hsieh [2005]. Sweetness was reported as high on 7 samples, middle on 3 samples and 3 samples was less sweet than the others. Furthermore, 2 samples were expressed as sour and highly sour [Yarilgaç and Yildiz 2001]. Besides color, properties such as fruit firmness, and sweetness were reported as different significant qualities from consumer's point of view [Serrano et al. 2005, Huang et al. 2009, Iglesias and Echeverría 2009]. In this research appearance, firmness, sweetness, grittiness, juiciness and overall quality of pear fruits were determined between 5.8–8.5, 4.5–8.4, 6.1–8.5, 5.2–8.0, 4.5–8.2 and 5.6–8.4 respectively. Stone cell contents were found inversely proportional to sensory grittiness scores. Statistical groups of juiciness and overall edibility quality displayed similarities. Fruits of 'Bağ' cultivar have the highest sensorial scores with 8.4 overall quality.

CONCLUSION

In this research important fruit characteristics were detected of 11 local variety and 'Maslovka' pear cultivars and it was concluded that 'Erkenci Buzbağ' 'Orak' and 'Bağ' had better fruit characteristics (fruit weight, phytochemical and sensory) than the others. So, they had potential for registration and certification as a new cultivar.

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FIZYCZNE, CHEMICZNE, SENSORYCZNE I BIOAKTYWNE CECHY LOKALNYCH I STANDARDOWYCH ODMIAN GRUSZY W TURCJI

Streszczenie. Badano niektóre ważne cechy fizyczne (barwa zewnetrzna owoców, zwartość miąższu, masa owoców, rozmiar owoców, pestka), chemiczne (popiół, pH, zawartość rozpuszczalnych substancji stałych, cukry, kwasowość oznaczona), sensoryczne (wygląd, zwartość, słodkość, chropowatość, soczystość i ogólna jakość) oraz bioaktywne (zdolność antyoksydacyjna, związki fenolowe, całkowita zawartość związków fenolowych, witamina C) jedenastu lokalnych i jednej standardowej odmiany gruszy. Wszystkie odmiany pochodziły z krajowego repozytorium w Centralnym Ogrodniczym Instytucie Badawczym w Ataturk w Turcji. Masa owoców wynosiła od 56,80 g (‘Kirmizi Biber’) do 128,94 g (‘Erkenci Uzun Sap’). Na podstawie wyników badań wnioskuje się, że odmiana ‘Bağ’ miała najwyższe noty sensoryczne (ogólna jakość 8,4) i zdolność antyoksydacyjną (21,44 mg ekwiwalent kwasu askorbinowego·g^{-1}). Sucha masa pestki wynosiła 63,65 (‘Gümüşhane’) i 81.65 mg·g^{-1} (‘Maslovka’). Odmiana ‘Orak’ wykazała największą zawartość kwasu chlorogenowego (185,98 mg·kg^{-1}) i epikatechiny (108,26 mg·kg^{-1}).

Słowa kluczowe: grusza, roślinne związki chemiczne, pestka, aktywność antyoksydacyjna

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