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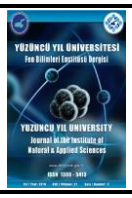

Research Article

Physical, Chemical and Bioactive Properties of Four Different Pears (*Pyrus communis L.*) Varieties Grown in Turkey

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Abstract: In this study, physical, chemical and bioactive properties of four different pear varieties (Mellaçi, Mellaki, Deveci and Margarite) grown in Turkey's eastern regions were investigated. It was determined that the length, diameter and weight values of pear varieties varied between 6.08-9.56 cm, 5.42-8.30 cm and 92.27-254.95 g, respectively. Also, glucose, fructose and sucrose amounts of pear varied between 15.43-22.83, 18.08-30.62, 1.36-14.77 g 100 g^{-1} d.m (dried matter), respectively. TPC, ABTS and DPPH results of pear varieties were determined 622.56-3718.43 mg GA eq kg^{-1} d.m, 18.35-178.90 mmol Trolox eq/g d.m and 149.49-366.07 mmol Trolox eq/g d.m, respectively. Syringic acid, chlorogenic acid, ferulic acid, ellagic acid, catechin, epicatechin and rutin were detected in pear samples. Chlorogenic acid was the major phenolic component in pear varieties. Also, it was determined that significant differences were found among pear varieties in terms of physical, chemical and bioactive properties. While the Mellaki variety showed superior properties in terms of analyzed physical properties, the Margarite variety had superior properties in terms of chlorogenic acid and antioxidant activity.

Türkiye'de Yetiştirilen Dört Farklı Armut (*Pyrus communis L.*) Çeşidinin Fiziksel, Kimyasal ve Biyoaktif Özellikleri

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Anahtar Kelimeler
Armut çeşitleri,
Biyoaktif bileşenler,
Fiziksel özellikler,
Kimyasal kompozisyon

Öz: Bu çalışmada, Türkiye'nin doğu bölgelerinde yetiştirilen dört farklı armut çeşidinin (Mellaçi, Mellaki, Deveci ve Margarit) fiziksel, kimyasal ve biyoaktif özellikleri araştırıldı. Armut çeşitlerinin boy, çap ve ağırlık değerlerinin sırasıyla 6.08-9.56 cm, 5.42-8.30 cm ve 92.27-254.95 g arasında değiştiği belirlendi. Ayrıca armudun glikoz, fruktoz ve sakaroz miktarları sırasıyla 15.43-22.83, 18.08-30.62, 1.36-14.77 g 100 g^{-1} KM (kuru madde) arasında değişmektedir. Armut çeşitlerinin TPC, ABTS ve DPPH sonuçları sırasıyla 622.56-3718.43 mg GA eq/kg KM, 18.35-178.90 mmol Trolox eq/g KM ve 149.49-366.07 mmol Trolox eq/g KM olarak belirlendi. Armut örneklerinde siringik asit, klorojenik asit, ferulik asit, elajik asit, kateşin, epikateşin ve rutin tespit edildi. Armut çeşitlerinde en fazla miktarda bulunan fenolik bileşen klorojenik asittir. Ayrıca, armut çeşitleri arasında fiziksel, kimyasal ve biyoaktif özellikler açısından önemli farklılıkların bulunduğu tespit edildi. Mellaki çeşidi analiz edilen fiziksel özellikler açısından üstün özellikler gösterirken, Margarit çeşidi klorojenik asit ve antioksidan aktivite açısından üstün özelliklere sahipti.

1. Introduction

Pear *(Pyrus communis L.)* is widely spread throughout the temperate regions of the world, such as China, America and Australia (Wang et al., 2021). Pyrus species are generally divided into two groups based on domestication area and geographic distribution. European pears (*P. communis*) are cultivated mostly in Europe and the U.S. and Asian pears (*P. pyrifolia, P. bretschneideri* and *P. ussuriensis*) grow in East Asian countries (Bennici et al., 2018). Turkey is an important pear-producer. Due to the favorable climate and soil conditions, it has a large number of species and varieties of pears (Okatan et al., 2017). However, a large number of local traditional varieties have been abandoned and replaced by modern varieties to meet the demands of both producers and consumers (Queiroz et al., 2019).

Consuming food products that are rich in antioxidants reduces the risk of developing chronic diseases and oxidative stress. Fruits and vegetables are an excellent source of substances with antioxidant and healthful properties. Such substances include polyphenols, carotenoids, and triterpenoids. Phenolic compounds have strong antioxidant, anti-inflammatory, antiviral, and anti-carcinogenic properties (Kolniak-Ostek et al., 2020). Pears rank relatively low among fruits regarding antioxidant activity and concentration of phenolics but have higher antioxidant activity than many common vegetables (Salta et al., 2010). Schieber et al. (2001) noted that in pear, the predominant phenolic constituents are chlorogenic, caffeic, p-coumaroyl quinic and p-coumaric acids, arbutin, several procyanidins and flavonol glycosides. Pear fruits are popular among consumers due to their sweetness, crispness, characteristic fragrance and slight aroma (Chen et al., 2007).

Although many studies have identified and quantified the phenolic compounds in different pear varieties grown in different regions, only a few of them focus on the chemical compounds in the Van province of East Anatolia grown *Pyrus communis L.* pear species, which include Mellaki, Mellaçi, Margarite and Deveci. Therefore, the objective of this study is to determine the physical and chemical properties, phenolic compositions and antioxidant activities of selected pear varieties.

2. Material and Methods

Mellaçi, Mellaki, Margarite and Deveci pears (*Pyrus communis L.*) were collected in September 2018 from Van province in Eastern Anatolia, Turkey. Samples were collected from six different regions (Erciş, Gevaş, Edremit, Şamranaltı, İskele and Akköprü). Pears were brought to the laboratory immediately. After washing, physical properties were determined, and then pears were stored in a deep freezer at -24 ºC until chemical analyzes were made.

2.1. Chemicals and reagents

Chromatography water (HPLC grade), methanol (HPLC grade), acetonitrile (HPLC grade), sodium carbonate, acetic acid and ethanol were purchased from Merck Company (Darmstadt, Germany). Folin ciocalteu, DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2-Azino-bis (3-ethylbenzthiazoline-6-sulfonic acid), catechin, epicatechin, syringic acid, chlorogenic acid, ellagic acid and rutine purchased from Sigma Aldrich (St. Louis, MO, USA).

2.2. Determination of some physical properties

The 24 collected pear samples were grouped. Five pears were randomly selected from among 24 pear samples. Diameter and length of five pear samples were measured by caliper and their weights were weighed on a scale. Water contents of pear samples were also determined according to the methods given by AOAC (AOAC, 2003).

2.3. Color measurements

L * (brightness, darkness), a * (redness, greenness) and b * (yellowness, blueness) values of peel and flesh of pear samples were measured and recorded with the Minolta CR 400 (Tokyo, Japan).

2. 4. Determination of some chemical content

Soluble solid concentration (SSC), ash, protein, pH and titratable acidity content of pears were determined according to the methods given by AOAC (AOAC, 2003).

2.5. Sugar content

Sugar content analysis was made according to Hamzaoğlu et al. (2018) method with some modifications. For fresh pears, 2.5 gram of sample was mixed with 25 ml of distilled water. The mixture was homogenized at 10,000 rpm for 10 s and then shaken at 180 rpm for 1 h with orbital shaker (OS-3000, JEIO TECH, Korea). The mixture centrifuged for 10 min at 3600x*g* and then filtrated with a 0.45 µm PVDF syringe filter prior to HPLC analysis. Chromatographic analyses were performed with HPLC system (Shimadzu, Kyoto, Japan). The HPLC system consisted of a RID-20A refractive index (RI) detector, a LC 20 AD gradient pump, a Rheodyne 7725i valve furnished with 20 µL loop, a SPD M20A photodiode array detector, CTO 10AS VP column oven, DGU 14A degasser, and a SCL 10A system controller. The eluent was water: acetonitrile (1:4 v/v) with a flow rate of 1.3 mL/min. The separation was performed using isocratic elution and the column temperature was 25 ºC. The compounds appearing in chromatograms were identified according to retention times and spectral data by comparison with standards.

2.6. Preparation of methanolic extracts

Methanolic extracts of fresh pear slices were prepared for use in phenolic content, DPPH and ABTS analysis. Methanolic extracts were prepared according to Bakkalbasi et al. (2013) with some modifications. 5.0 g of fresh samples were mixed with 10 mL methanol and the mixture was shaken on an orbital shaker (OS-3000, JEIO TECH, South Korea) for 2 h in the dark at room temperature. Then, the tubes were centrifuged at 8000x*g* for 10 min at 10 ºC. The same procedures were repeated 2 more times after the supernatant was removed. The supernatants were collected in an amber bottle. It was stored at -24 °C until analysis.

2.7. Determination of TPC (Total Phenolic Content)

The concentration of TPC was determined using Folin Cicalteu reagent, according to Singleton & Rossi (1965) with slight modifications. 0.4 mL of methanolic extractant was taken and placed in a test tube. 2 mL of Folin Ciocalteu and 1.6 mL of 7% sodium carbonate solution was added. The mixture was left in the dark at room temperature for 1 hour. It was measured and recorded in a spectrophotometer (UV Mini-1240, Shimadzu, Japan) set to 760 nm.

2.8. Antioxidant activity assay (DPPH and ABTS)

DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was determined according to Pyo et al. (2004) and ABTS (2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid) assay was determined according to Re et al. (1999). In a test tube, 3.6 mL of DPPH solution (0.025 g/L methanol) and 0.4 mL of methanolic extract were kept in the dark for 60 minutes at room temperature. At the end of the time, the absorbance of the sample was measured at 515 nm, and the inhibition rate of the DPPH radical was determined. The Trolox standard curve was used to calculate the results. As a first step for ABTS analysis, a 7 mM ABTS solution containing 2.45 mM potassium persulfate was prepared. Afterwards, this solution was kept in the dark at room temperature for 12-16 hours to allow the formation of stock ABTS+ radical solution. In the second step, ABTS working solution was prepared. The stock radical solution was diluted with ethanol and the absorbance of the ABTS+ working solution was adjusted to be 0.70 ± 0.02 at 734 nm. Then, 40 µL of extract was mixed with 1960 µL of ABTS+ working solution. After the mixture was kept in the dark for 6 min, its absorbance was read at 734 nm. The Trolox standard curve was used to calculate the results. The results were expressed as Trolox equivalent antioxidant capacity (mmol TE/g d.m).

2.9. Determination of phenolic compounds by HPLC

Phenolic compounds were made according to Colaric et al. (2005) method with slight modifications. Methanolic extracts were filtered through a 0.45 μm PVDF syringe driven filter (Millipore, Bedford, USA) and analyzed with HPLC. Separation of components was carried out using a C18 (250 × 4.6 mm id, particle size 5 μm) column (Waters, USA) at 25 °C. Mobile phase A is 2% acetic acid (v/v) in water and Mobile phase B is water: acetonitrile (1:1, v/v; B). The gradient program was as follows: 0 min 10% B; 30 min 20% B; 60 min 45% B. Detection was made at 280 and 320 nm for phenolic acids, 360 nm for flavanols. The compounds appearing in chromatograms were identified according to retention times and spectral data by comparison with standards.

2.10. Statistical evaluation

Analysis of the data was carried out using ANOVA (SPSS 20 program, IBM, USA). Differences between means were tested using Duncan's multiple range tests at $P< 0.05$.

3. Results and Discussion

Some physical properties of pear varieties were given in Table 1. It was found that the water, length, diameter and weight values of pear varieties varied between 80.04-83.68% 6.08-9.56 cm, 5.42-8.30 cm and 92.27-254.95 g, respectively. The highest average length, diameter and weight were determined in Mellaki pear samples. While the lowest diameter and weight values were detected in Margarite pears, the lowest average length was recorded in Mellaçi pear. The difference between the length, diameter and weight values of different pear varieties was found to be statistically significant ($P<0.05$). Kalkışım et al. (2018) stated that water content of 20 different pear varieties varied between 63.51-88.2%. Yarılgaç & Yıldız (2001) were measured the length, diameter and weight values of Mellaki pears collected from Adilcevaz province in Van Lake basin, 8.07-9.52 cm, 7.62-9.00 cm and 201.99-368.02 g, respectively. It was observed that the Mellaki pears' weight, length and diameter obtained in this study were lower than the those of the Mellaki pears collected in Adilcevaz. It may be due to the different harvest time, cultivation conditions and climatic factors.

Color values of pear varieties were given in Table 2. L *, a * and b * values of pear peel were 53.16-78.80, (-19.74) - (- 9.58) and 28.10-50.88, respectively. L *, a * and b * values of pear flesh were also 74.25-86.94, (-2.44) - (- 0.15) and 9.65-27.27, respectively. The highest L * and b * values of pear peel were recorded in Mellaki 3 sample and the lowest a * value was found in Margarite 1 samples. For fruit flash color of pears, L * values of fruit flesh of pear varieties were quite close to each. The highest L * value of pear flesh was found in Mellaki 4 sample. The highest a* and b * values were found in Mellaçi 2 variety. The difference amongst L * and b * values of pear peels was statistically significant ($P<0.05$). In the flesh color results, the difference between pear varieties was found to be insignificant ($P>0.05$). According to a study on two pear varieties (Santa Maria and Akcay, 77) grown in Turkey, L *, a * and b * values of the peels of two pear varieties were recorded as 74.23-76.95, (-10.85)- (-9.55) and 43.14-45.18, respectively. L *, a * and b * values of fruit flesh were also determined as 78.49-79.32, (-1.55)- (-2.27) and 9.37-11.80, respectively (Ekinci & Akçay, 2016). Oztürk et al. (2009) reported that the L *, a * and b * values of Deveci pear peel were 74.46, -3.40 and 37.28, respectively. It was observed that reported data were generally higher than our results for Deveci peel color values.

Table 1. Some physical properties of pear varieties

Sample	Water (%)	Length (cm)	Diameter (cm)	Weight (g)
Mellaçi variety				
1	83.68	8.73	5.85	145.21
2	80.47	6.08	5.42	92.27
3	83.11	6.27	5.85	105.60
4	81.55	7.90	6.80	160.51
5	81.79	8.25	6.81	167.94
6	81.31	7.61	6.60	140.27
7	80.04	7.65	6.48	139.63
8	81.96	8.40	6.37	143.27
9	82.90	8.25	6.94	157.35
10	81.02	7.92	6.77	151.76
11	80.94	7.91	6.58	143.27
Mean±SD	81.70±1.14^{a}	7.72±0.83^{ab}	6.41±0.49^{ab}	140.64±22.69^{a}
CV(%)	1.39	10.74	7.64	16.12
Mellaki variety				
1	81.91	8.21	7.97	213.01
2	83.26	8.80	7.56	223.39
3	80.27	7.47	7.15	150.51
4	82.80	7.78	6.17	142.46
5	82.90	7.13	6.78	142.88
6	82.12	8.90	7.70	222.68
7	81.74	9.56	7.72	253.82
8	81.10	8.82	8.30	254.95
9	82.07	7.43	6.49	180.48
Mean±SD	82.01±0.93^{a}	8.23±0.83^{b}	7.32±0.67^{b}	200.46±45.45^{b}
CV(%)	1.13	10.09	9.19	22.67
Margarite variety				
1	81.90	7.47	5.65	113.76
2	81.03	7.48	5.73	115.39
Mean±SD	81.46±0.62^{a}	7.48±0.01^{ab}	5.69±0.06^{a}	114.58±1.15^{a}
CV (%)	0.76	0.09	0.99	0.10
Deveci variety				
1	81.83	6.34	5.91	121.83
2	83.45	6.98	6.25	147.56
Mean±SD	82.64±1.15^{a}	6.66±0.45^{a}	6.08±0.12^{a}	134.69±18.19^{a}
CV (%)	1.39	6.79	1.97	13.50

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

Table 2. Peel and flesh color values of pear varieties

Sample	Fruit peel			Fruit flesh		
	L*	a*	b*	L*	a*	b*
Mellaçi variety						
1	70.04	-16.34	45.62	85.19	-0.86	19.70
2	73.97	-13.78	43.69	75.12	-0.15	27.27
3	67.31	-16.62	41.97	77.25	-1.65	27.02
4	71.70	-11.56	40.34	81.32	-1.57	19.64
5	74.06	-12.92	42.06	80.54	-1.59	20.23
6	75.49	-14.31	42.39	81.09	-1.73	20.96
7	74.90	-14.09	42.34	81.05	-0.56	20.97
8	76.96	-15.41	42.60	81.59	-1.52	18.56
9	76.44	-15.55	42.55	82.91	-1.70	18.52
10	76.79	-15.25	42.86	80.60	-1.66	18.94
11	76.74	-15.16	42.69	81.47	-1.53	19.29
Mean±SD	74.03±3.14^{b}	-14.63±1.5^{a}	42.64±1.28^{b}	80.74±2.65^{a}	-1.32±0.54^{a}	21.00±3.15^{a}
CV (%)	4.24	10.24	2.99	3.28	40.90	14.97
Mellaki variety						
1	71.09	-16.19	46.67	85.19	-0.74	19.70
2	68.71	-16.55	44.22	83.48	-1.77	15.79
3	78.80	-11.13	50.88	84.23	-0.71	21.28
4	66.87	-14.04	43.44	86.94	-2.15	15.40
5	66.26	-16.99	42.41	78.46	-1.64	24.93
6	72.95	-12.78	49.99	79.77	-2.02	21.71
7	72.52	-16.84	41.59	80.19	-0.56	16.77
8	68.15	-17.66	41.01	77.19	-1.13	23.47
9	72.47	-14.70	41.61	75.91	-0.59	9.65
Mean±SD	70.86±3.90^{b}	15.20±2.20^{a}	44.64±3.71^{b}	81.26±3.84^{a}	-1.25±0.64^{a}	18.74±4.79^{a}
CV (%)	5.51	14.47	8.30	4.72	51.13	25.53
Margarite variety						
1	53.16	-19.74	28.10	79.40	-1.14	25.08
2	62.24	-11.59	38.61	76.91	-2.00	21.30
Mean±SD	57.70±6.42^{a}	15.66±5.76^{a}	33.35±7.43^{a}	78.15±1.76^{a}	-1.57±0.61^{a}	23.19±2.67^{a}
CV (%)	11.13	36.79	22.28	2.25	38.73	11.53
Deveci variety						
1	56.39	-18.38	31.22	84.86	-2.44	15.75
2	65.59	-9.58	41.62	74.25	-1.36	12.67
Mean±SD	60.99±6.51^{a}	13.98±6.22^{a}	36.42±7.35^{a}	79.55±7.50^{a}	-1.90±0.76^{a}	14.21±2.18^{a}
CV (%)	10.67	44.51	20.19	9.43	40.19	15.33

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

Some chemical properties of pear varieties were also determined (Table 3). The SSC, ash and protein amounts of pear varieties varied between 13.30-15.40%, 0.25-0.71% (d.m) and 0.30-0.48% (d.m), respectively. The difference between protein values of pear varieties was found statistically significant ($P<0.05$). Mellaki variety has the lowest protein content. Kalkışım et al. (2018) stated that water, ash and protein values of 20 different pear varieties varied between 63.51-88.2%, 1.02- 6.37% and 1.04- 5.09%, respectively. The water values of the pear varieties in the reported study varied in a wide range including the moisture values we obtained. However, protein and ash values reported by

Kalkışım et al. (2018) were higher than our results. Yarılgaç & Yıldız (2001) stated that the SSC values of Mellaki pears varied between 13.80-15.40%. Our results were similar with findings of Yarılgaç & Yıldız (2001). Oztürk et al. (2009) determined the SSC values of Deveci pear as 14.00%, and this value was found to be lower than the SSC amount of Deveci pears in our study.

pH and acidity values of analyzed pear samples varied between 4.00-5.97 and 0.18-0.53%, respectively. It was observed that the highest pH and lowest acidity belonged to Mellaçi sample. However, for pH and acidity, the difference between pear varieties was found to be insignificant ($P>0.05$). Yarılgaç & Yıldız (2001) recorded that the pH and acidity values of 11 different pear varieties between 3.01-5.61 and 0.24-2.40%, respectively. Kalkisim et al. (2018) noted that the pH and acidity results of 20 different pear cultivars varied between 4.07-5.56 and 0.13-1.33%, respectively. Oztürk et al. (2009) determined the pH and acidity values of Deveci pear as 4.28, 0.60%, respectively. There are some differences between our results and declared results in the literature in terms of pH and acidity results. Although pH and acidity characteristic of pear varieties are specific to the genotype, also it may be due to that pH and acidity values vary according to the rootstock and soil conditions used (Oztürk et al., 2009).

Table 3. Some chemical properties of pear varieties

Sample	SSC (%)	Ash (% d.m)	Protein (% d.m)	pH	Acidity (% d.m)
Mellaçi variety					
1	15.10	0.36	0.36	4.00	0.53
2	14.90	0.48	0.38	5.57	0.23
3	14.40	0.47	0.43	5.14	0.28
4	13.90	0.29	0.42	5.96	0.18
5	15.00	0.67	0.32	5.91	0.23
6	14.80	0.31	0.39	5.97	0.20
7	13.90	0.31	0.43	5.97	0.18
8	14.10	0.42	0.36	5.85	0.19
9	15.20	0.57	0.31	5.83	0.31
10	13.30	0.35	0.39	5.78	0.26
11	15.20	0.32	0.41	5.70	0.30
Mean±SD	14.52±0.65[a]	0.41±0.12[a]	0.38±0.04[a]	5.60±0.59[a]	0.26±0.10[a]
CV (%)	4.44	29.63	10.79	10.44	38.14
Mellaki variety					
1	13.30	0.71	0.44	5.24	0.26
2	13.50	0.32	0.30	4.40	0.36
3	15.40	0.35	0.36	5.18	0.31
4	14.00	0.41	0.34	4.02	0.53
5	13.30	0.42	0.41	5.32	0.29
6	15.00	0.44	0.30	4.51	0.41
7	13.30	0.31	0.37	5.70	0.29
8	14.30	0.39	0.31	5.38	0.24
9	13.80	0.41	0.40	4.06	0.21
Mean±SD	13.98±0.78[a]	0.42±0.12[a]	0.35±0.05[a]	4.86±0.63[a]	0.40±0.22[a]
CV (%)	5.54	28.39	14.17	12.89	53.97
Margarite variety					
1	14.10	0.35	0.48	4.61	0.33
2	13.80	0.41	0.44	4.63	0.31
Mean±SD	13.95±0.21[a]	0.38±0.04[a]	0.46±0.03[b]	4.62±0.01[a]	0.32±0.01[a]
CV (%)	1.52	11.16	6.15	0.31	4.42
Deveci variety					
1	15.00	0.27	0.39	4.65	0.32
2	15.20	0.25	0.36	4.69	0.26
Mean±SD	15.10±0.14[a]	0.26±0.01[a]	0.37±0.02[a]	4.67±0.03[a]	0.29±0.04[a]
CV (%)	0.94	5.44	5.66	0.61	14.63

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

Individual sugar content in pear samples was given in Table 4. Glucose, fructose, sucrose and total sugar amounts of pear samples varied between 15.43 and 22.83, 18.08 and 30.62, 1.36 and 14.77, 44.55 and 53.54 g $100g^{-1}$ d.m, respectively. Fructose was major sugar and fructose/glucose ratio ranged from 1.10 to 1.33. Mellaki and Mellaci varieties had higher sucrose and lower glucose and fructose content than Margarite and Deveci varieties. The difference between the glucose, fructose, sucrose and total sugar results of pear varieties was statistically significant ($P<0.05$). Arzani et al. (2008) found the fructose, glucose and sucrose amounts of pears as 33.1, 31.1 and 3.3 g kg^{-1}, respectively.

Table 4. Sugar components of pear varieties

Sample	Glucose (g $100g^{-1}$ d.m)	Fructose (g $100g^{-1}$ d.m)	Sucrose (g $100g^{-1}$ d.m)	Total sugar (g $100g^{-1}$ d.m)
Mellaçi variety				
1	19.41	22.26	9.10	50.77
2	18.81	20.94	10.07	49.82
3	16.65	19.63	11.58	47.86
4	15.82	21.04	10.56	47.42
5	16.56	21.96	10.07	48.59
6	18.33	21.16	9.43	48.92
7	17.10	19.32	11.23	47.65
8	15.43	21.32	14.77	51.52
9	16.24	23.74	13.56	53.54
10	17.32	22.38	13.13	52.83
11	16.89	20.65	10.29	47.83
Mean±SD	17.14±1.25[a]	21.30±1.26[a]	11.25±1.83[b]	49.70±2.17[ab]
CV (%)	7.26	5.90	16.26	4.37
Mellaki variety				
1	16.46	20.56	9.73	46.74
2	19.05	19.81	7.47	46.33
3	16.99	18.08	9.48	44.55
4	19.24	20.94	5.11	45.29
5	18.29	19.02	10.39	47.70
6	19.94	21.99	8.81	50.74
7	19.74	20.50	10.55	50.79
8	18.71	20.21	8.96	47.88
9	17.48	21.17	7.00	45.65
Mean±SD	18.43±1.22[a]	20.25±1.17[a]	8.61±1.78[b]	46.97±2.71[a]
CV (%)	6.64	5.77	20.63	5.77
Margarite variety				
1	19.97	26.03	1.36	47.36
2	21.22	28.70	1.53	51.45
Mean±SD	20.59±1.89[c]	27.36±0.88[a]	1.44±0.12[a]	49.40±2.89[ab]
CV (%)	6.90	4.29	8.32	5.85
Deveci variety				
1	22.83	26.32	2.39	51.54
2	20.20	30.62	2.34	53.16
Mean±SD	21.51±1.86[b]	28.47±3.04[b]	2.36±0.04[a]	52.35±1.15[b]
CV (%)	8.64	10.68	1.49	2.19

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

TPC, ABTS and DPPH results of pear samples varied between 622.56-3718.43 mg GAE kg^{-1} d.m, 18.35-178.90 mmol Trolox eq/g d.m and 149.49-366.07mmol Trolox eq/g d.m, respectively (Table 5). While the Margarite variety had not highest total phenolic content, it had highest antioxidant activity. It may be due to the difference in the individual phenolic profile and the contribution of other antioxidant components such as pigments, amino acids, vitamins etc. For the TPC, ABTS and DPPH values, the difference amongst pear varieties was statistically significant ($P<0.05$). Kolniak-Ostek et al. (2020) stated that the TPC amount of pears ranged between 2188.93-6687.71 mg GAE /kg d.m. Erbil et al. (2018) determined the TPC and antioxidant activities of five pear varieties as 126.1-402.5 mg GAE/100 g and 0.81-1.72 µmol TE/g, respectively. Imeh & Khokhar (2002) reported the TPC of 4 different pear varieties as 302.3-458.2 mg GAE / 100g.

Table 5. TPC, ABTS and DPPH results of pear varieties

Sample	TPC (mg GAE kg^{-1} d.m)	ABTS (mmol Trolox eq/g d.m)	DPPH (mmol Trolox eq/g d.m)
Mellaçi variety			
1	2658.21	18.35	364.78
2	3450.30	84.10	366.07
3	3266.04	57.38	201.21
4	1693.15	63.39	218.00
5	1540.08	88.81	243.03
6	2014.53	81.10	181.88
7	1362.83	53.59	237.63
8	3627.63	68.72	219.56
9	1226.09	67.54	167.95
10	2933.12	63.34	149.49
11	2938.49	52.69	193.32
Mean±SD	2428.22±885.09[a]	63.54±19.26[a]	231.17±72.09[b]
CV (%)	36.45	30.31	31.18
Mellaki variety			
1	2676.88	55.16	228.90
2	2027.70	73.78	227.64
3	3480.12	168.62	214.24
4	3718.43	107.22	227.00
5	1265.52	98.83	170.29
6	1530.80	49.24	277.51
7	1258.96	67.64	259.76
8	1242.76	59.50	206.79
9	2945.85	134.78	250.98
Mean±SD	2366.95±248.70[a]	90.53±40.51[a]	229.23±31.52[b]
CV (%)	52.75	44.74	13.75
Margarite variety			
1	2059.71	178.90	287.88
2	2614.91	168.00	307.02
Mean±SD	2337.31±392.59[a]	173.45±7.71[b]	297.45±13.53[a]
CV (%)	16.80	4.44	4.55
Deveci variety			
1	2758.59	107.77	298.05
2	622.56	70.69	264.10
Mean±SD	1690.57±225.89[b]	89.23±26.22[a]	281.07±24.01[a]
CV (%)	89.34	29.38	8.54

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

Individual phenolics were determined in pear varieties and results were given in Table 6. Syringic, chlorogenic, ferulic and elagic acids as phenolic acid, catechin and epicatechin as flavan-3-ols and rutin as free flavonol were detected in pear samples. Chlorogenic acid and rutine were determined in all sample and varied between 125.07 and 410.74 mg kg^{-1} d.m, 13.43 and 185.13 mg kg^{-1} d.m, respectively. Chlorogenic acid was major phenolic compound in pear sample and Margarite variety showed superior properties in terms of chlorogenic acid. High antioxidant activity of Margarite variety may be related to their high chlorogenic acid content compared to other varieties. Catechin, epicatechin, syringic acid, ellagic acid and ferulic acids were minor phenolic compounds in pear varieties. However, only Deveci varietiy contents high epicatechin content. The difference amongst epicatechin and chlorogenic acid results of pear varieties was statistically significant ($P<0.05$).

Azzini et al. (2019) determined that the catechin and epicatechin concentrations of pear varieties collected from different regions of Italy varied between 3.71-4.16 mg /100 g and 2.93-4.21 mg /100 g, respectively. Li et al. (2014) found the catechin, epicatechin, rutine, chlorogenic acid and ferullic acid concentrations of 10 different pear varieties as 4.64-27.7, 4.88-29.00, 17.7-91.9, 12.0-407.5, 0.83-127.2 µg / g, respectively. In our study, there are similar results with reported data by Azzini et al. (2019) and Li et al. (2014). However, the differences between our results and reported results in the literatures for chemical and physical parameters may be due to the different variety, harvest time (Kutlu & Şen, 2011), agricultural techniques, climatic conditions and altitude (Aslantaş & Karakurt, 2007; Gülsoy et al., 2019).

Table 6. Phenolic composition of pear varieties (mg kg^{-1} d.m)

Sample	Catechin	Syringic	Epicatechin	Chlorogenic	Ellagic	Ferullic	Rutine
Mellaçi variety							
1	22.84	T.E	T.E	348.37	2.14	1.83	185.13
2	17.27	4.16	T.E	259.72	0.24	1.71	27.24
3	T.E	T.E	T.E	182.36	T.E	1.88	38.18
4	T.E	T.E	T.E	137.15	T.E	3.03	62.82
5	23.58	T.E	T.E	151.10	0.79	3.57	92.16
6	46.67	4.93	T.E	135.62	0.49	2.16	56.81
7	17.28	T.E	T.E	125.07	T.E	2.55	30.69
8	T.E	2.95	T.E	167.22	1.30	T.E	123.20
9	38.96	7.37	T.E	147.02	T.E	2.22	65.79
10	59.75	8.19	T.E	134.59	T.E	2.45	40.39
11	58.34	5.39	T.E	136.67	T.E	2.41	52.84
Mean±SD	25.88±22.30[a]	2.99±3.19[a]		174.99±68.76[a]	0.45±0.70[a]	2.16±0.90[a]	70.47±45.10[a]
CV (%)	86.19	106.39		39.29	156.10	41.58	63.99
Mellaki variety							
1	19.49	3.38	45.79	192.79	0.59	2.30	40.40
2	T.E	5.91	37.34	258.90	T.E	T.E	22.79
3	19.76	2.61	42.92	266.23	0.86	1.72	20.78
4	21.11	5.77	T.E	267.00	3.77	T.E	13.62
5	22.58	3.42	35.09	164.74	T.E	T.E	13.43
6	24.39	T.E	T.E	196.65	3.13	2.63	25.73
7	34.26	7.15	T.E	140.09	0.25	T.E	17.81
8	T.E	T.E	23.57	210.39	0.43	1.45	13.98
9	19.53	7.03	31.58	410.74	5.99	2.03	84.94
Mean±SD	17.90±11.13[a]	3.91±2.74[a]	24.03±19.10[a]	234.17±80.04[a]	1.66±2.12[a]	1.12±1.11[a]	28.16±22.91[a]
CV (%)	62.18	70.16	79.48	34.18	127.38	99.26	81.34
Margarite variety							
1	20.82	3.34	1.50	336.48	2.25	1.63	39.48
2	23.65	T.E	3.38	365.09	2.90	1.85	34.59
Mean±SD	22.23±2.01[a]	1.67±2.36[a]	2.44±1.32[a]	350.78±20.23[b]	2.57±0.45[a]	1.74±0.15[a]	37.03±3.45[a]
CV (%)	8.99	141.42	54.48	5.76	17.84	8.94	9.33
Deveci variety							
1	24.63	T.E	158.33	202.78	3.16	2.09	42.54
2	27.83	3.48	251.73	210.21	T.E	2.17	16.89
Mean±SD	26.23±2.26[a]	1.74±2.46[a]	205.03±66.04[b]	206.49±5.25[a]	1.58±2.23[a]	2.13±0.05[a]	29.71±18.13[a]
CV (%)	8.62	141.42	32.21	2.54	141.42	2.65	61.03

According to Duncan multiple comparison test, different lowercase letters show the difference between pear varieties ($P<0.05$).

4. Conclusion

This study aimed to determine of physical, chemical and bioactive properties of four pear varieties. Amongst the four varieties, Mellaki had the highest length, diameter and weight. Mellaki and Mellaçi varieties with high sucrose and low fructose content had the best sugar composition in terms of health. While Mellaki, Mellaçi and Margarite varieties had similar TPC, the best variety in terms of antioxidant activity was Margarite pear. Margarite pear with high antioxidant activity can be considered the best for direct consumption. Four different pear varieties were collected from the same regions. Mellaki and Mellaçi among pear varieties are of local variety and they have high commercial potential when their physical, chemical and bioactive properties are considered.

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