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Determination of Agromorphological and Biochemical Characteristics of Fruits of Plum Cultivars and Genotypes According to Different Maturity Stages*

Farklı Olgunluk Evrelerine Göre Erik Çeşit ve Genotiplerine Ait Meyvelerin Agromorfolojik ve Biyokimyasal Özelliklerinin Belirlenmesi*

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Abstract: This study was conducted on five commercial plum cultivars are grown in Iğdır province and five wild plum genotypes commonly found in the province. The pomological properties, vitamin C, organic acids contents and phenolic compounds contents of plum fruits were determined. As for the pomological properties, fruit weight was measured as 130.5 g in Autumn Giant cultivar, while fruit thickness was 56.4 mm, fruit length was 48.6 mm, and fruit width was 53.3 mm. The fruit stem length was 13.7 mm in Japanese cultivar. Among phytochemicals; in the highest titratable acidity was detected in Angelino cultivar (2.1%), while the highest soluble solid content was determined in Green Plum (21.4%), the pH in Type 5 genotype (3.7), vitamin C in Type 2 genotype (29.44 mg $100g^{-1}$); of organic acids, oxalic acid was determined to be the highest in Type 3 genotype (8.043 mg $100g^{-1}$), citric acid in Autumn Giant cultivar (27.142 mg $100g^{-1}$), malic acid in Black Splendor cultivar (5.121 mg $100g^{-1}$), succinic acid (5.541 mg $100g^{-1}$) and fumaric acid (7.071 mg $100g^{-1}$) was determined in Angelino cultivar. From phenolic compounds; gallic acid was determined to be the highest in Type 4 genotype (2.078 mg $100g^{-1}$), protocatechuic acid in Angelino cultivar (1.975 mg $100g^{-1}$), catechin in Type 4 genotype (6.971 mg $100g^{-1}$), chlorogenic acid (20.027 mg $100g^{-1}$) and vanillic acid (0.589 mg $100g^{-1}$) in Autumn Giant cultivar, caffeic acid in Type 4 genotype (1.016 mg $100g^{-1}$), syringic acid in Type 4 genotype (0.982 mg $100g^{-1}$), p-coumaric acid in Angelino cultivar (1.712 mg $100g^{-1}$), ferulic acid in Type 5 genotype (1,647 mg $100g^{-1}$), o-coumaric acid in Angelino cultivar (0.388 mg $100g^{-1}$), rutin in Black Splendor cultivar (0.981 mg $100g^{-1}$). It has been observed that there is a great diversity among the plum genotypes.
Keywords: Plum, Ripening, Phenolic compounds, Pomology, Organic acids.

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Öz: Bu çalışma, Iğdır'da yetiştirilen beş ticari erik çeşidi ve yaygın olan beş yabani erik genotipi üzerinde yürütülmüştür. Erik meyvelerinin pomolojik özellikleri, fenolik bileşik içerikleri, organik asit içerikleri ve C vitamini miktarı tespit edilmiştir. Pomolojik özellikler arasında meyve ağırlığı, meyve kalınlığı, meyve boyu ve meyve genişliği Autumn Giant çeşidinde sırasıyla 130.5 g, 56.4 mm, 48.6 mm, 53.3 mm olarak daha yüksek ölçülmüşken, meyve sap uzunluğu Japon çeşidinde 13.7 mm olarak tespit edilmiştir. Fitokimyasallardan; titre edilebilir asitlik Angelino çeşidinde (% 2.1), suda çözünür kuru madde içeriği Can Eriğinde (%21.4), pH Tip 5 genotipinde (3.7), C vitamini Tip 2 genotipinde (29.44 mg $100g^{-1}$); organik asitlerden okzalik asit Tip 3 genotipinde (8.043 mg $100g^{-1}$), sitrik asit Autumn Giant çeşidinde (27.142 mg $100g^{-1}$), malik asit Black Splendor çeşidinde (5.121 mg $100g^{-1}$), süksinik asit (5.541 mg $100g^{-1}$) ve fumarik asit (7.071 mg $100g^{-1}$) Angelino çeşidinde daha yüksek belirlenmiştir. Fenolik bileşiklerden; gallik asit (2.078 mg $100g^{-1}$) Tip 4 genotipinde, protokateşuik asit (1.975 mg $100g^{-1}$) Angelino çeşidinde, kateşin (6.971 mg $100g^{-1}$) Tip 4 genotipinde, klorojenik asit (20.027 mg $100g^{-1}$) ve vanilik asit (0.589 mg $100g^{-1}$) Autumn Giant çeşidinde, kafeik asit (1.016 mg $100g^{-1}$) ve siringik asit (0.982 mg $100g^{-1}$) Tip 4 genotipinde, p-kumarik asit (1.712 mg $100g^{-1}$) Angelino çeşidinde, ferulik asit (1.647 mg $100g^{-1}$) Tip 5 genotipinde, o- kumarik asit (0.388 mg $100g^{-1}$) Angelino çeşidinde ve rutin (0.981 mg $100g^{-1}$) Black Splendor çeşidinde daha yüksek ölçülmüştür. Erik genotipleri arasında büyük bir çeşitliliğin olduğu görülmüştür.
Anahtar Kelimeler: Erik, Olgunluk, Fenolik bileşik, Pomoloji, Organik asit.

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INTRODUCTION

Undoubtedly, the plum is one of the temperate climate fruit species with the widest genetic base (Aslantaş, 2017). Due to this feature, it is one of the fruits that spread to a wide area in Turkey as well as and in the world today. In addition to a large number of species, the fact that they originate from regions with different climates played an important role in the spread of plum over such a wide area, and thus it is a fruit that can be seen on the market stalls for a long time (Özvardar and Önal, 1990; Durmuş and Yiğit, 2003; Özçağıran et al., 2011).

Plum fruit is rich in many minerals and vitamins which are necessary for a healthy life. In addition, plums contain high amounts of potassium, phosphorus, calcium and magnesium. Plum consumption is recommended for arterial hypertension patients due to its high potassium content and useful sodium/potassium ratio (Lucas et al., 2004). Plum, which has high nutritional properties and low calorie content; contains carbohydrates such as fructose, sucrose, and glucose, which determine the nutritional value and taste; organic acids such as malic acid and citric acid; aromatic components, vitamins, high fiber content, carotenoids, anthocyanins, flavonoids and phenolic substances (Ertekin et al., 2006). Plum is rich in bioactive compounds such as vitamins A, C and E, anthocyanins and other phenolic compounds and is a good source of natural antioxidants (Rupasinghe et al., 2006). Public health studies have shown that the consumption of fruits and vegetables is effective in preventing diseases due to the phenolic compounds they contain. The most effective way to take these disease-preventing factors is to increase the consumption of fruits and vegetables rich in antioxidants (Hashim et al., 2005). Increased consumption of fruits and vegetables has been associated with a decrease in the incidence of degenerative diseases, thanks to the high antioxidant capacity of these phytonutrients (Schreiner and Huyskens-Keil, 2006).

Due to the high genetic diversity, the production and consumption of plums is increasing both in Turkey and around the world due to the long harvest season, delicious flavor, high nutritional value, and ease of cultural processes (Karamürsel, 2011).

Fruits have an important place in the daily diet and their effects on human health have been known since ancient times. Fruits, which are important for human health and nutrition, have very important phytochemical components. The amounts of these phytochemicals vary according to the type of fruit, variety, maturity status, growing technique, and ecological conditions (Sülüsoğlu et al., 2014; Aslantaş, 2017). Many studies have demonstrated the protective roles of phenolic compounds against coronary heart disease, stroke and some forms of cancer. These protective effects of phenolic compounds are due to their antiradical activities in cells (Parr and Bolwell, 2000).

It has been reported that, in general, the relationship between the antioxidant substance content in the fruit and the phenolic substance content is very important (Cevallos-Casals, 2002). Anthocyanins in fruits are the most important type of polyphenols, and they are one of the phenolic compounds responsible for the color of fruits. The concentration and composition of anthocyanins are important for the sensory quality of fruits and products, in addition to their possible health benefits. Phenolic substances are effective in the formation of flavor in fruits, especially in the feeling of a bitter taste in the mouth. Anthocyanins are phenolic compounds and cause the unique colors of vegetables and fruits. In addition, the catalyzing effects of polyphenoloxidase enzymes can cause browning of products obtained from fruits and vegetables in reactions. Phenolic compounds, which have an important effect in the fruit juice processing industry, are also effective in the clouding of and in the formation of sediment in such beverages as fruit juices and wine (Cemeroğlu et al., 2004).

In this study, five commercial plum cultivars grown in Iğdır province and five wild plum genotypes commonly found in the province were considered. The phenolic compounds and organic acid contents of the fruits taken from the plum genotypes in the raw and ripe period, as well as some fruit characteristics, were determined in the study.

MATERIAL AND METHOD

In the study, five different plum cultivars (Autumn Giant, Angelino, Black Splendor, Japanese Plum and Green Plum) and five different wild plum genotypes common grown in Iğdır province were used as material. The study was carried out in 2018. The fruits of the cultivars and genotypes picked from the producer orchards in the central and central district villages of Iğdır were collected both in the unriped and riped periods.

Morphological Properties

30 fruits from each tree were picked and their weight weighed on a 0.01 g sensitive scale. Using a 0.01 mm precision digital caliper; the fruit thickness (mm) of the collected fruit samples were measured. The fruit length (mm) was determined by measuring the part between the fruit stalk and flower pit, while the fruit width (mm) was determined by measuring the distance between the two cheeks. The average fruit stem length (mm) was determined by measuring the distance between the part where the fruit stalk connects to the fruit and the part breaking off from the branch. Five randomly selected fruits were crushed and juiced, and the amount of soluble solid content (SSC) was determined as % with the help of a digital refractometer (Model HI-96801 Hanna, German). The pH of the juice was measured by keeping the electrode type of the pH meter (Hanna-HI98103) in the juice, and recording the value displayed on the screen when it became stable. Titratable acidity was determined by the titration method as suggested by Kılıç et al. (1991) and given as %.

Phenolic Compounds Analysis

Gallic acid, protocatechuic acid, catechin, chlorogenic acid, caffeic acid, p-coumaric acid, ferulic acid, o-coumaric acid, vanillic, rutin and syringic acid were the phenolic compounds determined in the study. In the analysis of phenolic compounds by HPLC, the method suggested by Rodriguez-Delgado et al. (2001) was adapted and used. The samples taken were diluted with distilled water at a ratio of 1:1 and centrifuged at 15000 rpm for 15 minutes. Then, the upper part was filtered with 0.45 μm millipore filters and injected into HPLC. Chromatographic separation was performed on Agilent 1100 (Agilent) HPLC system using DAD detector (Agilent. USA) and 250*4.6 mm, 4μm ODS column (HiChrom, USA). Separation was carried out at 254 and 280 nm using Solvent A Methanol-acetic acid-water (10:2:88) and Solvent B Methanol-acetic acid-water (90:2:8) as mobile phases, and the flow rate was determined as 1mL $min.^{-1}$ while the injection volume was determined as 20 μL.

Organic Acids Analysis

The fruit samples were kept in deep freezer (-20°C) until analysis. Succinic acid, oxalic acid, citric acid, malic acid, fumaric acid and ascorbic acid (vitamin C) were the organic acids determined in the study. The method given by Bevilacqua and Califano (1989) was modified and used for the extraction of organic acids. 5 g of fruit samples were taken and placed in centrifuge tubes. These samples were homogenized by adding 20 ml of 0.009 N H_2SO_4 (Heidolph Silent Crusher M, Germany). Then it was mixed for 1 hour on a mixer (Heidolph Unimax 1010, Germany) and centrifuged at 15,000 rpm for 15 minutes. The aqueous fraction separated in the centrifuge was first passed through coarse filter paper, then twice through a 0.45 μm membrane filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA) and finally through the SEP-PAK C_{18} cartridge. Organic acids were analyzed in an HPLC instrument (Agilent HPLC 1100 series G 1322 A, Germany) performing the method recommended by Bevilacqua and Califano (1989). In the HPLC system, Aminex HPX - 87 H, 300 mm x 7.8 mm column (Bio-RadLaboratories, Richmond, CA, USA) was used and the device was managed with a computer with Agilent package program. The DAD detector (Agilent. USA) in the system was tuned to 214 and 280 nm wavelengths. In the study, 0.009 N H_2SO_4 passed through a 0.45 μm membrane filter was used as the mobile phase.

Vitamin C Analysis

For ascorbic analysis, 5 g of the fruit sample was taken and transferred to a test tube, and 5 ml of 2.5% M-phosphoric acid solution was added. The mixture was centrifuged at 6500 x g for 10 minutes at + 4 °C. 0.5 ml was taken from the clear part in the centrifuge tube and made up to 10 ml by adding 2.5% M-phosphoric solution. This mixture was filtered through a 0.45 μm Teflon filter and injected into the HPLC device. In

HPLC analysis, vitamin C analysis was carried out on a C_{18} column (PhenomenexLuna C_{18}, 250 x 4.60 mm, 5 µ). The column furnace temperature was set at 25°C. Ultrapure water with pH level adjusted to 2.2 with H_2SO_4 at a flow rate of 1 ml/min was used as the mobile phase in the system. Readings were carried out in a DAD detector at a wavelength of 254 nm. L–ascorbic acid (Sigma A5960) prepared at different concentrations (50, 100, 500, 1000, 2000 ppm) was used to identify and quantify the vitamin C peak (Cemeroğlu, 2007).

Evaluation of the Data

Descriptive statistics ($X \pm S_X$) for each feature studied are shown as mean and standard error. One-way analysis of variance was used for each pomological trait studied. Tukey's multiple comparison test was used to identify significant differences between genotypes. MINITAB 17 (Trial version) statistical software was used in the analysis of the data.

RESULTS AND DISCUSSION

Morphological Properties

As can be seen from Table 1, the differences between the values reached in terms of pomological characteristics were found to be statistically significant in fruit samples taken during the unripe and fully ripe periods ($p<0.05$). Fruit weight increased with ripening in all genotypes and varied between 9.6 g (Type 2) and 130.5 g (Autumn Giant). The fruit size of plum cultivars grown in different ecologies may vary. It was reported by Balık (2005) that the average fruit weight of Autumn Giant in Kahramanmaraş ecology was 70.95g. Fruit thickness also varied between cultivars and with ripening. Fruit thickness, fruit length and fruit width were measured as 56.4, 48.6 and 53.3 mm, respectively, in the Autumn Giant cultivar. It has been reported that Autumn Giant and T.C. Sun cultivars grown in Van ecology stand out in terms of fruit length, fruit height, fruit weight and fruit thickness (Bostan, 1997). According to the results of a study by Ertekin et al. (2006) carried out in Antalya province, the changes in fruit length and width are caused by the difference in variety and ecology. Fruit stem length also varied between cultivars and genotypes. Yaşar et al., (2022) reported that fruit weight, fruit width, fruit height and fruit height between 56.69-80.31 g, 44.28-50.40 mm, 40.37-48.41 mm, 47.13-53.19 mm respectively in the 15 promising black plum genotypes selected in Iğdır.

Variations between fruit characteristics detected in plums may be due to differences in their genetic structures. Because there may be differences in developmental physiology even if the formation physiology is the same between genotypes. Cell division coefficient after fertilization and cell growth ability close to harvest may be different. This situation may also be related to the growing conditions and fruit load of the plant (Aslantaş, 2017).

The amount of soluble solid content increased with ripening and was found to be higher especially in plum cultivars. The soluble solid content varied between 5.5% and 21.4%. Although the pH of the juice differs between the cultivars, it was measured between 2.5 and 3.6 (Table 2). The amount of titratable acid was recorded between 0.7% and 2.1%. Güneş (2003) determined that the titratable acid content of some plum cultivars grown in Tokat differed between cultivars. In a study conducted in Isparta province, Subaşı (2013) determined that the content of soluble solid content differs between plum cultivars. Kuba (2015) explained that the differences determined in the genotypes of plums grown naturally in the Van region may be due to the variety and ecological characteristics.

Phenolic Compounds

In fruits belonging to plum genotypes, gallic acid content was found to be varying between 0.421 and 2.078 mg 100 g^{-1}, while protocatechuic acid content was between 0.319 and 1.975 mg 100 g^{-1}, catechin content between 1.031 and 6.971 mg 100 g^{-1}, chlorogenic acid content between 7.040 and 20.027 mg 100 g^{-1}, and vanillic acid content between 0.094 and 0.589 mg 100 g^{-1}. The caffeic acid content was determined between 0.421 and 1.192 mg 100 g^{-1}, syringic acid content between 0.269 and 0.982 mg 100 g^{-1}, ferulic acid content 0.374 and 1.647 mg 100 g^{-1}, while the p-coumaric acid content varied between 0.427 and 1.712 mg 100 g^{-1}, the o-coumaric acid content between 0.068 and 0.388 mg 100 g-1, and the rutin content between 0.085 and 0.981 mg 100 g^{-1} (Table 3).

Table 1. Fruit weight (g), fruit thickness (mm), fruit length (mm), fruit stem length (mm), and fruit width (mm) of plum fruits

Çizelge 1. Erik meyvelerinin meyve ağırlığı (g), meyve kalınlığı (mm), meyve boyu (mm), meyve sap uzunluğu (mm) ve meyve genişliği (mm).

	Cultivars and Genotypes	Fruit Weight	Fruit Thickness	Fruit Length	Fruit Stem Length	Fruit Width
UNRIPE	Autumn Giant	31.5 ± 1.581b	22.2 ± 0.508d	22.0 ± 0.771e	3.9 ± 0.376ef	20.4 ± 0.359c
	Angelino	22.3 ± 0.410c	18.9 ± 0.198e	14.5 ± 0.317g	4.5 ± 0.272e	19.5 ± 0.171c
	Japanese	11.7 ± 0.801d	7.9 ± 0.430g	19.7 ± 0.378f	1.1 ± 0.179g	9.6 ± 0.407d
	Green Plum	10.4 ± 0.255d	10.6 ± 0.241f	9.6 ± 0.356h	3.1 ± 0.172f	9.9 ± 0.180d
	Black Splendor	57.3 ± 1.990a	48.9 ± 0.316a	42.8 ± 0.303a	12.8 ± 0.465a	43.9 ± 0.246a
	Type 1	8.7 ± 1.468d	23.9 ± 0.428c	27.3 ± 0.206c	13.2 ± 0.590a	24.9 ± 0.889bc
	Type 2	3.1 ± 0.014e	0.7 ± 0.146i	2.2 ± 0.091i	9.6 ± 0.323b	2.6 ± 0.117ef
	Type 3	10.9 ± 0.734d	27.5 ± 0.252b	24.6 ± 0.149d	6.6 ± 0.225c	26.5 ± 0.315b
	Type 4	5.4 ± 0.208e	3.4 ± 0.090h	9.9 ± 1.396h	7.6 ± 0.151c	3.6 ± 0.238e
	Type 5	31.1 ± 0.107b	23.5 ± 0.101c	30.5 ± 0.265b	5.5 ± 0.299d	23.4 ± 0.026bc
RIPE	Autumn Giant	130.5 ± 1.648a	56.4 ± 3.710a	48.6 ± 1.949a	11.2 ± 0.498c	53.3 ± 2.848a
	Angelino	44.8 ± 0.222b	38.5 ± 3.101bc	47.9 ± 18.448a	2.9 ± 0.020g	38.5 ± 3.222b
	Japanese	39.3 ± 1.116c	37.7 ± 0.950bcd	47.1 ± 0.476a	13.7 ± 0.402a	39.7 ± 0.393b
	Green Plum	26.4 ± 2.452e	35.2 ± 1.020cde	30.1 ± 0.810ab	12.8 ± 0.510b	33.5 ± 0.414bc
	Black Splendor	18.9 ± 6.494f	31.3 ± 2.512de	28.4 ± 2.441ab	13.7 ± 1.702a	32.7 ± 1.506bc
	Type 1	37.4 ± 10.044c	42.5 ± 7.493b	38.2 ± 6.320ab	8.8 ± 1.086e	40.1 ± 7.210b
	Type 2	9.6 ± 2.342g	24.6 ± 1.954f	23.7 ± 1.402b	10.1 ± 0.258cd	23.5 ± 2.233d
	Type 3	17.9 ± 2.990f	29.6 ± 0.358ef	23.8 ± 3.017b	9.5 ± 0.347d	27.7 ± 0.578cd
	Type 4	28.5 ± 0.619e	31.2 ± 3.438de	31.2 ± 3.969ab	11.7 ± 1.477c	27.3 ± 4.588cd
	Type 5	31.1 ± 0.686d	23.6 ± 0.042f	30.1 ± 0.033ab	6.2 ± 0.065f	23.7 ± 0.215d

*: The difference between the averages shown with different letters in the same column is significant at the 0.05 level.

The most important reason for the increase in studies on phenolic compounds in recent years is that they have a high level of protective properties against diseases that cause oxidative damage, such as heart disease, stroke, and cancer (Beccaro et al., 2006). It is known that phenolic compounds strongly affect fruit quality and contribute to both sensory properties and nutritional values. In a study conducted in Ecuador on different fruit species from the Rosaceae family and in plum fruits, some phenolic compounds and their derivatives were determined in different amounts (Vasco et al., 2009).

Organic Acids

Oxalic acid, citric acid, malic acid, succinic acid, fumaric acid and vitamin C contents were determined in the fruits of the plum genotypes examined in this study, and the results are presented in Table 4. Organic acids in fruits also affect different physiological changes, especially taste formation. When the data were examined, statistically significant differences were found between cultivars and genotypes in terms of organic acid content ($p<0.05$). Among the determined organic acids, citric acid was the highest and dominant organic acid, varying between 5.132 mg 100 g^{-1} and 27.142 mg 100 g^{-1} in the fruits of all genotypes. Among other organic acids, oxalic acid was detected between 3.260 and 8.043 mg 100 g^{-1}, malic acid between 1.135 and 5.121 mg 100 g^{-1}, succinic acid between 0.690 and 5.541 mg 100 g^{-1}, and fumaric acid between 0.213 and 7.071 mg 100 g^{-1}. In addition, vitamin C content varied between 11.078 and 29.442 mg per 100 g^{-1} and higher values were determined in fully ripe plum fruits.

Table 2. Soluble solid content (%), pH and titratable acidity contents (%) of plum fruits.
Çizelge 2. Erik meyvelerinin suda çözünür kuru madde (%), pH ve titre edilir asitlik (%) içerikleri.

	Cultivars and Genotypes	SSC	pH	TA
UNRIPE	Autumn Giant	8.9 ± 0.058b	3.1 ± 0.046bc	1.8 ± 0.066a
	Angelino	8.2 ± 0.458cd	3.2 ± 0.078bc	2.1 ± 0.038a
	Japanese	9.1 ± 0.696ab	3.2 ± 0.082bc2	1.5 ± 0.189b
	Green Plum	8.1 ± 0.839cd	3.6 ± 0.080a	0.9 ± 0.052c
	Black Splendor	7.4 ± 0.088d	3.3 ± 0.147b	2.0 ± 0.070a
	Type 1	9.6 ± 0.581a	3.1 ± 0.043bc	1.5 ± 0.052b
	Type 2	9.6 ± 0.692a	3.1 ± 0.032bc	1.4 ± 0.042b
	Type 3	5.5 ± 0.058e	2.9 ± 0.084c	1.3 ± 0.068b
	Type 4	7.0 ± 0.115d	3.1 ± 0.096bc	0.9 ± 0.064c
	Type 5	8.5 ± 0.865c	3.7 ± 0.095a	1.0 ± 0.075c
RIPE	Autumn Giant	13.5 ± 1.539bc	3.1 ± 0.048bc	1.1 ± 0.064c
	Angelino	14.8 ± 0.370bc	2.5 ± 0.168de	1.1 ± 0.050c
	Japanese	11.5 ± 1.328cd	2.8 ± 0.106cde	1.2 ± 0.078bc
	Green Plum	21.4 ± 2.312a	3.2 ± 0.124ab	0.8 ± 0.063cd
	Black Splendor	11.8 ± 2.126cd	2.7 ± 0.133ef	1.3 ± 0.168b
	Type 1	8.3 ± 0.935d	2.9 ± 0.098bcd	1.7 ± 0.192a
	Type 2	11.4 ± 1.015cd	2.9 ± 0.205bcd	1.4 ± 0.310ab
	Type 3	8.1 ± 2.780d	3.5 ± 0.145a	1.1 ± 0.032c
	Type 4	15.9 ± 1.220b	3.0 ± 0.063bc	0.8 ± 0.219cd
	Type 5	12.0 ± 2.121c	3.2 ± 0.090bc	0.7 ± 0.052e

*: The difference between the averages shown with different letters in the same column is significant at the 0.05 level.

The findings of this study are mostly in line with other research pointing out the richness of fruits in terms of organic acids. Differences in studies may be related to the species, cultivars, practices, environmental conditions, and genetic factors examined (Gündoğdu and Yılmaz, 2012). During the ripening of the fruit, citric acid tends to decrease, while malic acid tends to be irregular and vitamin C tends to increase (Ornelas-Paz et al., 2013).

Organic acids and sugars are the main factors affecting the sensory properties of fruits. The organic acid-sugar ratio is also an important criterion that characterizes fruit flavor. Organic acids in the fruit are effective in taste and aroma, not only in fresh consumption, but also in processed products. Organic acids show antioxidant properties, which is a factor that explains their widespread use for pharmacological purposes. Organic acid content, which has a decisive influence on fruit flavor, varies by genotype and variety (Ikegaya et al., 2019).

The plum cultivars examined in this study are commercial cultivars that are widely grown in Turkey, both for fresh consumption and in the food industry. Iğdır province has a great potential in terms of fruit growing due to its microclimatic conditions. However, plum cultivation has not been given enough attention in the province. This study, it was aimed to determine the fruit and yield characteristics of five plum cultivars grown in Iğdır province, as well as the organic acids, vitamin C content and phenolic compounds in the fruits. Examination of these parameters is important on plum cultivation and determining fruit quality in Iğdır ecology.

Table 3. Phenolic compound contents of plum fruits (mg 100g^{-1}).
Çizelge 3. Erik meyvelerinin fenolik bileşik içerikleri (mg 100g^{-1}).

	Cultivars and Genotypes	Gallic acid	Protocatechuic acid	Catechin	Chlorogenic acid	Vanillic acid	Caffeic acid
UNRIPE	Autumn Giant	0.986±0.004e	1.340±0.036c	3.074±0.009c	20.027±0.473a	0.530±0.015a	0.691±0.004de
	Angelino	0.712±0.007g	1.975±0.005a	1.319±0.003h	8.642±0.031f	0.125±0.002f	0.966±0.011b
	Japanese	1.786±0.006b	0.421±0.005g	2.049±0.006e	11.382±0.272d	0.094±0.002g	0.473±0.014f
	Green Plum	0.561±0.004h	0.870±0.007e	4.131±0.011a	9.511±0.039e	0.096±0.003g	0.767±0.014cd
	Black Splendor	0.986±0.002e	0.949±0.002d	1.428±0.006g	11.208±0.082d	0.094±0.004g	0.718±0.007d
	Tip 1	0.421±0.002i	0.319±0.008h	2.317±0.004d	13.340±0.118c	0.215±0.004d	0.816±0.006c
	Tip 2	1.324±0.005c	0.652±0.004f	1.982±0.007f	15.532±0.404b	0.308±0.007c	0.481±0.009f
	Tip 3	0.759±0.006f	0.459±0.004g	1.187±0.007i	13.289±0.022c	0.213±0.003d	0.620±0.002e
	Tip 4	2.078±0.006a	1.384±0.005b	3.582±0.012b	7.487±0.064g	0.436±0.011b	1.192±0.082a
	Tip 5	1.150±0.001d	0.860±0.004e	1.031±0.009j	9.667±0.211e	0.165±0.003e	0.525±0.011f
RIPE	Autumn Giant	0.736±0.002f	1.088±0.007b	3.738±0.018c	18.451±0.120a	0.589±0.011a	0.474±0.014g
	Angelino	0.650±0.001h	1.248±0.006a	1.564±0.009h	7.552±0.042f	0.136±0.003f	0.887±0.007b
	Japanese	0.421±0.008j	0.406±0.005f	2.261±0.011e	10.300±0.020c	0.105±0.004g	0.433±0.007h
	Green Plum	0.484±0.006i	0.716±0.012c	5.443±0.008b	9.254±0.053e	0.173±0.004e	0.626±0.016e
	Black Splendor	0.858±0.007d	0.606±0.004d	1.848±0.007g	9.814±0.062d	0.107±0.004g	0.731±0.008d
	Tip 1	0.784±0.001e	0.416±0.006f	2.562±0.005d	10.377±0.019c	0.295±0.004d	0.822±0.012c
	Tip 2	1.156±0.007b	0.580±0.009e	2.119±0.008f	12.786±0.431b	0.366±0.004c	0.421±0.011h
	Tip 3	0.707±0.001g	0.417±0.006f	1.306±0.005i	9.392±0.159de	0.280±0.007d	0.525±0.013f
	Tip 4	1.813±0.013a	1.066±0.014b	6.971±0.009a	7.040±0.030g	0.550±0.007b	1.016±0.013a
	Tip 5	1.068±0.012c	0.628±0.004d	1.216±0.006j	7.843±0.023f	0.186±0.001e	0.519±0.010f

	Cultivars and Genotypes	Syringic acid	p-Coumaric acid	Ferulic acid	o-Coumaric acid	Rutin
UNRIPE	Autumn Giant	0.828±0.009b	0.644±0.011h	0.524±0.008e	0.152±0.007e	0.763±0.006a
	Angelino	0.339±0.013g	1.712±0.006a	0.931±0.009b	0.388±0.007a	0.123±0.005h
	Japanese	0.520±0.010e	0.773±0.010g	0.880±0.010c	0.217±0.006c	0.243±0.004e
	Green Plum	0.722±0.008c	0.823±0.012f	0.853±0.012c	0.385±0.008a	0.085±0.004i
	Black Splendor	0.427±0.011f	1.566±0.010b	0.868±0.005c	0.117±0.003f	0.228±0.006e
	Tip 1	0.680±0.010d	0.578±0.007i	0.488±0.006f	0.124±0.005f	0.320±0.010d
	Tip 2	0.736±0.017c	0.861±0.004e	0.866±0.011c	0.109±0.005f	0.474±0.007c
	Tip 3	0.327±0.007g	0.872±0.006e	0.726±0.008d	0.308±0.007b	0.143±0.003g
	Tip 4	0.982±0.017a	1.320±0.013c	0.426±0.007g	0.192±0.004d	0.207±0.006f
	Tip 5	0.430±0.014f	1.016±0.011d	1.647±0.014a	0.119±0.005f	0.665±0.007b
RIPE	Autumn Giant	0.756±0.007a	0.613±0.012f	0.477±0.012f	0.106±0.005e	0.858±0.017c
	Angelino	0.289±0.008f	1.287±0.010a	0.913±0.010b	0.334±0.008a	0.468±0.012f
	Japanese	0.463±0.009d	0.610±0.009f	0.652±0.006e	0.184±0.004c	0.315±0.013g
	Green Plum	0.644±0.006b	0.759±0.008de	0.774±0.009d	0.328±0.006a	0.161±0.006i
	Black Splendor	0.376±0.006e	1.219±0.014b	0.811±0.008c	0.096±0.002ef	0.981±0.014a
	Tip 1	0.522±0.012c	0.427±0.009g	0.413±0.012g	0.086±0.007f	0.815±0.008d
	Tip 2	0.631±0.013b	0.784±0.014d	0.780±0.008cd	0.068±0.005g	0.569±0.012e
	Tip 3	0.269±0.010f	0.748±0.007e	0.636±0.015e	0.282±0.007b	0.192±0.004i
	Tip 4	0.741±0.011a	1.209±0.008b	0.374±0.009h	0.147±0.005d	0.272±0.007h
	Tip 5	0.380±0.009e	0.969±0.008c	1.381±0.017a	0.085±0.005fg	0.926±0.013b

*: The difference between the averages shown with different letters in the same column is significant at the 0.05 level.

Çizelge 4. Organic acid contents of plum fruits (mg $100g^{-1}$).
Table 4. Erik meyvelerinin organik asit içerikleri (mg $100g^{-1}$).

	Cultivars and Genotypes	Oxalic acid	Citric acid	Malic acid	Succinic acid	Fumaric acid	Vitamin C
UNRIPE	Autumn Giant	5.824±0.003de	27.142±0.018a	2.215±0.001e	1.198±0.001j	1.160±0.014h	15.324±0.142f
	Angelino	5.278±0.160e	18.175±0.015e	3.860±0.008b	5.541±0.027a	7.071±0.016a	20.161±0.035b
	Japanese	7.964±0.323ab	25.673±0.032b	3.804±0.051c	2.218±0.050d	1.932±0.009g	16.514±0.364e
	Can Erik	4.477±0.246f	9.770±0.003h	1.372±0.011h	1.741±0.003g	5.511±0.029c	15.189±0.187f
	Black Splendor	6.371±0.352d	16.149±0.019f	5.121±0.008a	3.540±0.030b	6.277±0.174b	15.066±0.063f
	Tip 1	4.159±0.004f	17.738±0.023e	2.128±0.011f	2.138±0.008e	2.223±0.052f	13.171±0.016g
	Tip 2	6.122±0.022d	13.506±0.275g	2.232±0.006e	1.544±0.029h	0.634±0.011i	23.286±0.186a
	Tip 3	8.043±0.073a	7.134±0.001i	2.704±0.005d	2.408±0.007c	3.144±0.023e	19.138±0.017c
	Tip 4	7.334±0.004c	20.849±0.526c	1.752±0.003g	1.986±0.010f	0.577±0.003i	23.537±0.415a
	Tip 5	7.399±0.090bc	20.174±0.024d	3.893±0.005b	1.325±0.003i	3.356±0.007d	17.213±0.161d
RIPE	Autumn Giant	3.260±0.024g	24.856±0.032a	1.832±0.014g	0.690±0.006h	0.574±0.020h	21.488±0.073ab
	Angelino	4.519±0.008b	13.012±0.011f	2.848±0.011d	1.324±0.014d	5.567±0.030a	24.171±0.035a
	Japanese	5.174±0.041a	20.841±0.023b	3.133±0.006b	1.320±0.023d	0.942±0.006e	22.499±0.182ab
	Can Erik	3.733±0.022e	8.138±0.018i	1.135±0.014i	1.395±0.004c	3.138±0.002b	19.340±0.218ab
	Black Splendor	4.126±0.007d	11.039±0.014h	3.414±0.018a	1.096±0.023g	1.459±0.012d	19.272±0.139ab
	Tip 1	3.542±0.030f	13.912±0.001e	1.980±0.001f	1.666±0.002b	0.831±0.026f	18.443±0.310ab
	Tip 2	5.144±0.022a	11.476±0.018g	1.985±0.009f	1.187±0.000f	0.213±0.007j	29.442±0.109a
	Tip 3	5.157±0.032a	5.132±0.011j	2.046±0.005e	1.959±0.005a	2.558±0.028c	11.078±11.078b
	Tip 4	4.318±0.049c	15.586±0.020d	1.304±0.007h	1.402±0.015c	0.380±0.008i	25.396±0.155a
	Tip 5	5.213±0.003a	16.252±0.042c	2.944±0.001c	1.228±0.011e	0.728±0.007g	23.478±0.238a

*: The difference between the averages shown with different letters in the same column is significant at the 0.05 level.

CONCLUSION

The consumption of plum is increasing both in Türkiye and in the world due to its rich nutritional elements and health benefits. In addition to fresh consumption, plums are processed in the industry and used in various ready-made foods, and as well demanded as a raw material in the jam, marmalade, compote, syrup and molasses industry or are utilized by drying.

In the present study, the pomological properties in plums, including fruit weight, fruit width, fruit length, and fruit stem length characteristics were investigated. The superiority of the pomological properties of the fruit is one of the most important factors affecting the market value of the product. When all investigated genotypes are compared, it is seen that the commercially-important cultivars are physically superior (more attractive than) the local genotypes. pH, SSC, amount of titratable acidity are among the factors that affect the fruit taste and eating quality of plum. It can be stated that plum is a species whose range is quite wide in terms of consumer groups and preference situations.

Organic acids are effective in many physiological events such as taste formation in fruits and ripening. If these acids, which are effective on taste, are at low levels, then the fruits become sweeter, and if they are found at high levels, they become sour. When we compare the results we have obtained with the prior studies, it is seen that we have obtained values close to those found in the literature.

As a result of this study, organic acid and phenolic contents of the fruit juices of the cultivars were determined. It is thought that the difference between cultivars and genotypes, in terms of the results achieved, are caused by factors such as genetic factors, climate, soil structure, cultural practices and annual average precipitation.

When the obtained data are evaluated, it is thought that the phytochemicals and pomological properties of the plum fruit vary between cultivars and genotypes, and this will constitute an important resource for breeding studies.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DECLARATION OF AUTHOR CONTRIBUTION

The authors contributed equally to the study.

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