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Original article

Biochemical characteristics of sweet cherry germplasm in Turkey

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Summary. In this study, phenolic compounds, organic acids, sugars, vitamin C and total antioxidant activities of national (0900 Ziraat, Malatya Dalbasti and Sari Kiraz) and universal (Merton Late, Vista, Bing and Lambert) sweet cherry cultivars and one genotype (1355) were investigated. We determined fourteen phenolic compounds, five organic acids and three sugars in sweet cherry fruit. In general, gallic, vanilic and ellagic acid were major phenolic compounds in fruit of sweet cherry cultivars and genotype. The genotype1355 had more phenolic compounds compared to cultivars. It was determined that malic acid was frequently determined among the fruit of investigated cultivars and genotype. It was observed the highest sugar content was measured in 1355 genotype and 0900 Ziraat cultivar. Total antioxidant capacity was the highest (9.22 μmol TE g^{-1}) in fruit of cultivar 0900 Ziraat. Overall the genotype 1355 found the most promising due to having favorable properties and could be recommended for farmers and consumers.

Key words: Antioxidant capacity, phenolic compounds, *Prunus avium*, organic acids, sugars

Introduction

In recent years, fruits have become important for health due to the high phenolic compounds. It is well known that these substances increase antioxidant capacity in fruits and studies are progressing in this direction (1, 2). Some researchers reported that in addition these phenolic substances, the other biochemicals substances such as organic acids and anthocyanins play important role in increasing antioxidant activity (3). The most important phenolic compounds contained in sweet cherry fruits are known as phenolic acids (chlorogenic) and flavonoids (epicatechin) (4) and bioactive content and antioxidant capacity of sweet cherry depends on the cultivars and genotypes (5, 6). Ecological factors also affect the phenolic content and total antioxidant capacity of the fruit (7).

The phenolic compounds, the secondary metabolic products of plants, are group of substances having wide range of variations in the plants and the structure of thousands of phenolic compounds have been determined more recently (8). They are densely available in the seeds, flowers, leaves, bodies etc. of fruits and vegetables (9, 10).

The phenolic compounds are generally classified into two groups as phenolic acids and flavonoids. The flavonoids which are polyphenolic antioxidants are naturally available in the herbal teas, fruits and vegetables. Some part of phenolic compounds is very effective in the formation of taste of fruits and vegetables and principally formation of two significant taste aspects such as bitterness and sourness in the mouth. While other part provides the formation of colors such as yellow, yellow-brunet, red-blue tons in the fruits and veg-

etables. However, these compounds lead to enzymatic browning during the fruits and vegetables processing and making them new products. These cases are very significant in terms of fruits and vegetables processing and the products obtained from them (9).

Organic acids and sugars play an important role in fruit consumption and quality in the food industry. Ages, ecological conditions and genetic factors of plants affect the organic acid and sugar contents of fruits. Studies on sugar and organic acid contents emphasize that sweet cherry fruits are rich in glucose (11, 12) and malic acid and fumaric acid (3, 13).

Sweet cherry fruit are harvested at the beginning of summer. The chemical contents of fruit, such as phenolic substance and vitamin C, also affects consumption positively. According to the statistical data base of FAO (Food and Agricultural Organization), Turkey has an important producer of sweet cherries with 500 000 tons of production (14).

To date, no detailed studies in particular phenolic compounds has not been done on the sweet cherry cultivars and genotypes commonly grown and consumed in Turkey. It is utmost important for the growers to use sweet cherry cultivars with beneficial traits attracting consumer attention. Here, we particularly sought to get information about the phenolic compounds, organic acids and sugar and vitamin C content of seven sweet cherry cultivars and one newly selected genotypes having potential for cultivar registration.

Materials and Methods

Plant material

In this study, national and universal sweet cherry cultivars and one genotype were used as plant material. The fruit were hand-harvested at the full maturity stage. The examined cultivars were grafted onto seedling rootstock (*Prunus avium* L.), planted at 6 x 5 m spacing. 2 kg of fruit samples were collected homogeneously from the cultivars (Malatya Dalbasti, 0900 Ziraat, Merton Late, Vista, Bing, Sari Kiraz, Lambert) and genotype (1355). The samples were stored for a short duration at -80°C and analyses were immediately started against the risk of decay and loss of vitamin C contents.

Analysis of phenolic compounds

In the study, the gallic acid, ellagic acid, catechin, chlorogenic acid, caffeic acid, syringic acid, *p*-coumaric acid, ferulic acid, *o*-coumaric acid, phloridzin, protocatechuic acid, vanillic acid, rutin and quercetin were determined as phenolic compounds.

In the separation of phenolic acids with HPLC, the method developed by Rodriguez-Delgado *et al.* (15) was modified and used. The samples collected were distilled with distilled water at the ratio of 1:1 and after they were centrifuged at 15000 rpm for 15 min. The supernatant was filtered with 0.45 µm millipore filters and then injected to HPLC. The chromatographic separation was conducted by using DAD detector (Agilent. USA) and 250*4.6 mm, 4µm ODS colon (HiChrom, USA) in Agilent 1100 (Agilent) HPLC system. Solvent A Methanol-acidic acid-water (10:2:88), Solvent B Methanol-acidic acid-water (90:2:8) were used as the mobile phase. The separation was conducted at 254 and 280 nm and the flow rate was determined as 1 mL/min. and the injection volume was determined as 20 µL.

Analysis of organic acids

The samples collected were kept at -20 °C until the time of analysis. In the extraction of organic acids, the method developed by Bevilacqua and Califano (16) was modified and used. 5 g sample was taken from the fruit samples obtained and transferred to centrifuge tubes. These samples were homogenized by adding 20 ml 0.009 N H_2SO_4 (Heidolph Silent Crusher M, Germany). Then, it was mixed on the agitator (Heidolph Unimax 1010, Germany) for 1 h and centrifuged at 15000 rpm for 15 min. The aqueous part which was separated at centrifuge was filtered from first coarse filter paper, then 0.45 µm membrane filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA) for two times and finally SEP-PAK C18 cartridge. The organic acids were analyzed in HPLC device (Agilent HPLC 1100 series G 1322 A, Germany) by using the method developed by BEVILACQUA AND CALIFANO (1989). In HPLC system, Aminex HPX - 87 H, 300 mm x 7.8 mm colon (Bio-Rad Laboratories, Richmond, CA, USA) was used and the device was controlled with the computers including Agilent package program. DAD detector in the system (Agilent,

USA) was set to 214 and 280 nm wavelengths. In the study, 0.009 N H_2SO_4 filtered at 0.45 µm membrane filter was used as mobile phase.

Analysis of vitamin C

Vitamin C content was detected with modified HPLC procedure suggested by Cemeroglu (9). 5 ml of the fruit extracts was supplemented with %2.5 (w/v) metaphosphoric acid (Sigma, M6285, 33.5%), then centrifuged at 6500 rpm for 10 min at 4 ˚C. 0.5 ml of the mixture was brought to final volume of 10 ml with %2.5 (w/v) metaphosphoric acid. Supernatants were filtered with 0.45 µm PTFE syringe filter (Phenomenex, UK). C18 column (Phenomenex Luna C18, 250 x 4.60 mm, 5 µ) was used for the identification of ascorbic acid at temperature of 25 ˚C. Ultra distilled water with 1 ml/min flow rate and pH of 2.2 (acidified with H_2SO_4) was used as a mobile phase. Spectral measurements were made at 254 nm wavelength using DAD detector. Different standards of L-ascorbic acid (SigmaA5960) (50, 100, 500, 1000 and 2000 ppm) were used for quantification of ascorbic acid readings.

Determination of trolox equivalent antioxidant capacity (TEAC)

Trolox equivalent antioxidant capacity (TEAC) was determined with ABTS by dissolving in acetate buffer using potassium persulphate (17). For longer stability, the mixture was diluted with 20 mM sodium acetate buffer in acidic pH of 4.5, and read at 734 nm wavelengths, 0.700 ± 0.01. For spectrometric assay, 3 ml $ABTS^{+}$ was mixed with 20 µl fruit extract sample and incubated for 10 min, at 734 nm wavelengths for absorbance detection.

Sugar Analysis

The modified method of Melgarejo *et al*. (18) was used for sugar (fructose, glucose and sucrose) analyses. 5 ml of fruit extracts was centrifuged at 12000 rpm for 2 min at 4 ˚C. Supernatants were passed by SEP-PAK C18 cartridge. HPLC readings were made with µbondapak-NH_2 column using 85% acetonitrile as liquid phase with refractive index detector (RID). Fructose and glucose standards were used for sugar calculations.

Statistical Analysis

The study was designed as three repetitions and 20 fruit per repetition. The introductory statistics belonging to analysis and measurement results was offered as average ± standard deviation. In the statistical evaluations, SPSS 20 was used and the differences between the means was evaluated by subjecting to analysis of variance (ANOVA) and determined with Duncan multiple comparison test ($p<0.05$).

Results and Discussion

In this study, phenolic compounds, organic acids, vitamin C, sugars and total antioxidant values in fruits of seven sweet cherry cultivars and one genotype were identified. Statistically significant differences among cultivars and genotype were found ($p<0.05$). Among them 1355 sweet cherry genotype has come into prominence with five phenolic compounds (catechin, vanilic, ellagic, ferulic and *p*-coumaric acids). Sweet cherry cultivars and genotype contained high level gallic, vanilic and ellagic acid and chlorogenic and protocatechuic acid were found lower level. While the highest quercetin value was observed in Dalbasti cultivar (7.93 mg 100 g^{-1}), the highest catechin value was noted in 1355 genotype (8.03 mg 100 g^{-1}). (Table 1, 2). Consistent with our study, catechin value was previously reported to be 2.92 mg 100 g^{-1} in 0900 Ziraat cultivar (4). In another study, the amount of quercetin in sweet cherry fruits varied from 0.42 to 0.87 mg kg^{-1} depending on the rootstock used (19). Öztürk et al. (20) reported that the rootstocks were acted on the biochemical content of the fruits. In an earlier study, the total flavonoid content was determined as 208.33 mg kg^{-1} in the Napoleon cultivar in Turkey (21). The difference is thought to be due to the fact that the flavonoids are composed of many acids and the method is used different.

The Lambert cultivar was determined to be the most rutin and phloridizin values. Rutin values ranged from 2.47 to 11.89 mg $100g^{-1}$ and 1355 genotype had at least value (Table 1, 3). While the highest phloridizin was recorded in the Lambert cultivar as 4.23 mg $100g^{-1}$, the minimum value was recorded as 2.19 mg $100g^{-1}$ in the 0900 Ziraat cultivar (Table 3). In a differ-

Table 1. Protocatechuic, vanillic, ellagic, rutin and quercetin contents of cherry fruit (mg $100g^{-1}$).

Cultivars and genotype	Protocatechuic	Vanillic	Ellagic	Rutin	Quercetin
Dalbastı	1.75 ± 0.05f*	11.00 ± 0.07f	10.50 ± 0.63b	8.18 ± 0.03b	7.93 ± 0.02a
0900 Ziraat	2.72 ± 0.01c	12.80 ± 0.03c	10.64 ± 0.69ab	4.77 ± 0.02e	7.30 ± 0.02b
Merton Late	0.99 ± 0.05g	12.13 ± 0.05d	11.91 ± 0.16ab	11.86 ± 0.04a	6.73 ±0.03c
Vista	5.11 ± 0.03b	4.98 ± 0.04h	11.08 ± 0.60ab	7.30 ± 0.06c	1.08 ± 0.03h
Bing	1.89 ± 0.05e	13.59 ± 0.03b	11.20 ± 0.46ab	6.34 ± 0.04d	6.26 ± 0.02f
1355	0.56 ± 0.05h	19.65 ± 0.12a	12.20 ± 0.20a	2.47 ± 0.26f	3.23 ± 0.01g
Sarı Kiraz	5.35 ± 0.09a	8.09 ± 0.02g	10.45 ± 0.08b	6.66 ± 0.02d	6.47 ± 0.03d
Lambert	2.09 ± 0.02d	11.25 ± 0.03e	11.40 ± 0.31ab	11.89 ± 0.03a	6.37 ± 0.03e

*: Difference between means represented with the same letter in the same column is not significant at 0.05 level.

ent study, rutin values were expressed as 3.06 mg 100 g^{-1} in the Burlat cultivar and 13.69 mg 100 g^{-1} in the Saco cultivar (22). This study was parallel to our finding in general however there are bit difference that could be due to genetic background and climatic potential of the growing areas where cultivars exists. However, as opposed to our study, Hayaloglu and Demir (23) reported that the most rutin value was determined as 3.13 mg 100 g^{-1} in Merton Late cultivar, whereas Lambert contained the least rutin value as 1.34 mg $100g^{-1}$. Although the cultivars are the same, it is thought that the reason for the higher rutin values of our study is due to ecological factors.

Gallic acid is dominant in the phenolic compound. This acid, varies from 23.99 to 50.45 mg 100 g^{-1} in studied cultivars. Bing cultivar enjoyed the highest while Dalbastı cultivar have the lowest (Table 2). On the protocatechuic acid, the Sarı Kiraz cultivar was predominant with 5.35 mg 100 g^{-1}. 1355 genotype have the highest vanillic and ellagic acid values as 19.65 mg 100 g^{-1} and 11.91 mg 100 g^{-1}, respectively. Vista and Sarı Kiraz have lowest values of vanillic acid and ellagic acid, respectively. The highest syringic value was obtained from the 0900 Ziraat cultivar. Jakobek *et al*. (19) found ellagic acid value as 0.53 mg kg^{-1} in variety grafted on MaxMa 14 rootstock. In a study conducted in different varieties, the gallic acid level varied between 0.68 mg 100 g^{-1} (Dalbasti) and 10.64 mg 100 g^{-1} (Vista) (23). In our study, these values were higher than other previous studies. These differences are thought to be due to genetic or ecological factors.

The highest *p*-coumaric and ferulic acid (5.03 and 10.77 mg 100 g^{-1}, respectively) was obtained in 1355 genotype. The highest *o*-coumaric acid value was determined in Sarı cultivar (13.85 mg $100g^{-1}$) (Table 3).The value of *p*-coumaric acid was expressed as 26.6 mg 100 g^{-1} in the Larian cultivar and 13.72 mg 100 g^{-1} in the 0900 Ziraat cultivar in a study of Kelebek and Selli (4). In another study, ferulic acid and *p*-coumaric acid values were determined as 1.6 mg kg^{-1}, 0.8 mg kg^{-}

Table 2. Gallic, catechin, chlorogenic, caffeic and syringic contents of cherry fruits (mg 100 g^{-1}).

Cultivars and genotype	Gallic	Catechin	Chlorogenic	Caffeic	Syringic
Dalbastı	23.99 ± 0.06e*	1.05 ± 0.05g	3.55 ± 0.04a*	3.76 ± 0.03f	2.78 ± 0.05bc
0900 Ziraat	30.87 ± 0.11d	1.00 ± 0.01g	2.52 ± 0.02b	3.08 ± 0.03	3.80 ± 0.05a
Merton Late	36.59 ± 0.06c	1.24 ± 0.02f	2.23 ± 0.01d	4.61 ± 0.02e	2.88 ± 0.03bc
Vista	39.98 ± 0.02c	3.57 ± 0.03b	1.51 ± 0.04e	5.52 ± 0.13d	3.14 ± 0.47b
Bing	50.45 ± 0.470a	1.64 ± 0.02e	1.19 ± 0.01f	13.76 ± 0.03a	2.63 ± 0.06bc
1355	37.85 ± 2.99c	8.03 ± 0.10a	2.42 ± 0.02c	11.26 ± 0.04b	2.31 ± 0.02c
Sarı Kiraz	29.71 ± 0.73d	2.01 ± 0.01d	1.57 ± 0.05e	3.02 ± 0.07g	3.10 ± 0.04b
Lambert	45.05 ± 1.26b	2.52 ± 0.02c	1.08 ± 0.02g	6.96 ± 0.07c	1.65 ± 0.05d

*: Difference between means represented with the same letter in the same column is not significant at 0.05 level.

Table 3. *p*- Coumaric, ferulic, *o*-coumaric and phloridizin contents of cherry fruits (mg $100g^{-1}$).

Cultivars and genotype	*p*-coumaric	Ferulic	*o*-coumaric	Phloridizin
Dalbastı	3.17 ± 0.06b*	7.47 ± 0.02b	8.48 ± 0.03f	3.84 ± 0.02c
0900 Ziraat	2.84 ± 0.05d	5.00 ± 0.01e	7.90 ± 0.04g	2.19 ± 0.02e
Merton Late	3.07 ± 0.05bc	5.10 ± 0.04e	12.50 ± 0.05c	2.90 ± 0.04d
Vista	3.20 ± 0.03b	7.43 ± 0.03b	9.07 ± 0.07d	2.99 ± 0.04d
Bing	2.94 ± 0.06cd	6.47 ± 0.03d	8.66 ± 0.04e	3.99 ± 0.03b
1355	5.03 ± 0.05a	10.77 ± 0.05a	5.09 ± 0.02h	2.56 ± 0.04e
Sarı Kiraz	2.33 ± 0.02e	7.51 ± 0.01b	13.85 ± 0.05a	2.99 ± 0.02d
Lambert	2.85 ± 0.02d	7.10 ± 0.08c	13.67 ± 0.07b	4.23 ± 0.04a

*: Difference between means represented with the same letter in the same column is not significant at 0.05 level.

^{1}, respectively (1). The highest amount of caffeic acid was recorded in the Bing cultivar as 13.76 mg $100g^{-1}$, while the highest chlorogenic acid value was recorded in the Dalbastı cultivar. Sari Kiraz cultivar had the lowest caffeic acid contents. The chlorogenic acid value was expressed as 6.32 mg 100 g^{-1} in the Van cultivar (22) and between 0.67-2.92 mg 100 g^{-1} in 24 different sweet cherry cultivar in a study conducted by Ballistreri *et al*. (13). In contrast to our work, Hayaloglu and Demir (23) reported that the Lambert cultivar had the highest chlorogenic acid value.

When organic acid values of sweet cherry fruits were examined, there was variation according to cultivars and genotype. It was determined that the sweet cherry fruits contained the most malic acid. This was followed by succinic, citric, fumaric and oxalic acid. The lowest and the highest organic acid values were generally determined in Lambert and Vista cultivars, respectively. Highest malic acid was obtained from the 1355 genotype (34.70 g kg^{-1}). Vista cultivar dominated the highest values for succinic and oxalic acid. It is interesting to note that malic acid values were three times higher than succinic acid and about five times higher than fumaric acid (Table 4). They also reported that malic acid increases with maturation. According to the researchers, succinic and citric acid varied between 0.2-0.4% (24). According to Girard and Kopp (11), malic acid values obtained was about 20 times higher than succinic acid values in Lambert and Bing cultivars. Some researchers have identified fumaric acid levels changed between 0.12-1.14 mg 100 g^{-1} in different cultivars (13). Oxalic acid was investigated by Hayaloglu and Demir (25) in different sweet cherry cultivars and recorded at maximum as 4.25 g kg^{-1} in Bing cultivar. In general, lower values were obtained in our study, and this difference was attributed to ecological factors affecting organic acid values.

Depending on the genotype and cultivars, the amount of sugar has been determined to vary. Glucose was the major sugar, while sucrose was the least sugar.

Table 4. Organic acids content of cherry cultivars and genotype.

Cultivars and genotype	Oxalic (g kg^{-1})	Citric (g kg^{-1})	Malic (g kg^{-1})	Succinic acid (g kg^{-1})	Fumaric (mg kg^{-1})
Dalbastı	0.71 ± 0.010d*	4.42 ± 0.06e	13.06 ± 0.03g	6.79 ± 0.04e	2.52 ± 0.02e
0900 Ziraat	1.01 ± 0.020b	5.80 ± 0.05c	17.44 ± 0.05f	7.39 ± 0.03d	1.64 ± 0.02g
Merton Late	1.02 ± 0.040b	5.28 ± 0.02d	17.94 ± 0.03e	6.76 ± 0.03e	3.56 ± 0.02d
Vista	1.18 ± 0.025a	6.95 ± 0.03b	26.84 ± 0.09b	10.37 ± 0.03a	4.35 ± 0.04b
Bing	0.83 ± 0.030c	2.79 ± 0.04f	20.17 ± 0.05d	7.42 ± 0.03d	5.88 ± 0.07a
1355	0.15 ± 0.05ef	2.71 ± 0.03f	34.70 ± 0.04a	10.18 ± 0.07b	4.42 ± 0.07b
Sarı Kiraz	0.09 ± 0.00f	9.89 ± 0.08a	23.23 ± 0.07c	8.73 ± 0.03c	3.88 ± 0.04c
Lambert	0.21 ± 0.05e	1.73 ± 0.01g	7.77 ± 0.05h	5.22 ± 0.04f	2.10 ± 0.01f

*: Difference between means represented with the same letter in the same column is not significant at 0.05 level.

The highest amount of glucose had been determined in 0900 Ziraat cultivar (12.13 g 100 g^{-1}). Fructose and sucrose were detected as 6.2 and 1.95 g 100 g^{-1} in the 1355 genotype, respectively (Table 5). Consistent with our study, it has been reported that glucose and fructose are major sugars in sweet cherry fruit (24, 26). Fructose and glucose values were determined as 6.8-6.1 g 100g^{-1}, respectively (26). In another study, the glucose value was reported as about 10 times higher in the Lambert cultivar and about 17 times higher in the 0900 Ziraat than the sucrose value obtained in our study (119.85 and 7.6 g 100 g^{-1}) (12). Kelebek and Selli (4) obtained sucrose and fructose values as 0.51-1.10 g 100 g^{-1}, 38.41- 41.49 g 100 g^{-1} in four sweet cherry cultivars, respectively.

Vitamin C and total antioxidant activity were differed significantly by cultivars and genotype. In this study, the highest vitamin C value was determined in 1355 genotype (17.0 g 100 g^{-1}). It was determined that the 0900 Ziraat cultivar had the highest antioxidant activity determined by TEAC (8.22 μmol TE g^{-1}) method. The total antioxidant value was obtained at least in the Sari Kiraz cultivar. Along with being in harmony with our research, Ozturk *et al.* (27) reported that the total antioxidant value was determined as 8.10 μmol TE g^{-1} in 0900 Ziraat cultivar. Total antioxidant capacity was determined an average of 34.37 mg AEAC 100 g^{-1} by Kocak and Bal (28), as 283.25-439.10 mg Trolox 100 g^{-1} by Serradilla *et al.* (29) and was highest in Dalbastı cultivar as 6.15 mg TE g^{-1} by Hayaloglu and Demir (25). The difference with other researches is thought to be caused by the difference in method and cultivars used. This study revealed that correlations between *p*-coumaric, ferulic, malic, catechin, sucrose were determined statistically significant (Table 6). In this study there is a statistically significant and positive correlation between protocatechuic acid, vanillic acid and citric acid. This study has also been found that the same relationship exists between vanillic acid and *p*-coumaric acid. When the relationship between sugars and phenolics is examined, statistically significant levels have been determined between fructose with chlorogenic acid, *o*-coumaric acid and phlorodizin (P≤0.01).

Conclusion

In the present study, gallic acid was dominant among phenols, glucose among sugars and malic acid among organic acids in all cultivars and genotype. The 1355 genotype was determined to important in terms of phenolic compounds and vitamin C. 0900 Ziraat cultivar came into prominence with sugar and total antioxidant value. In terms of organic acid content, it has been determined that the Vista cultivar has superiority. It has been found that some chemical contents such as phenolic compounds in cherry fruits vary depending on the cultivars and genotype. In addition to these cultivars which are grown in our country, 1355 genotype used in our study should be recommended to cheery growers and should be cultivated and should be added to fruit juice and food sector to increase their consumption in terms of health.

Table 5. Sugars, TEAC and vitamin C contents of cherry cultuvars and genotype.

Cultivars and genotype	Glucose (g 100g^{-1})	Fructose (g 100g^{-1})	Sucrose (g 100g^{-1})	Vitamin C (g 100g^{-1})	TEAC (μmol TE g^{-1})
Dalbastı	10.14 ± 0.01d*	5.29 ± 0.03c	1.16 ± 0.05d	11.77 ± 0.02e	7.12 ± 0.01c
0900 Ziraat	12.13 ± 0.04a	5.94 ± 0.04b	0.97 ± 0.05f	9.86 ± 0.06g	8.22 ± 0.02a
Merton Late	9.20 ± 0.03e	4.10 ± 0.03e	1.23 ± 0.02c	10.91 ± 0.05f	6.14 ± 0.05e
Vista	10.09 ± 0.01d	4.95 ± 0.03d	1.30 ± 0.02b	15.04 ± 0.04b	7.19 ± 0.02c
Bing	9.23 ± 0.02e	3.16 ± 0.01h	0.95 ± 0.01f	14.50 ± 0.01c	6.22 ± 0.03d
1355	11.23 ± 0.04c	6.20 ± 0.07a	1.95 ± 0.02a	17.00 ± 0.30a	6.09 ± 0.02e
Sarı Kiraz	9.26 ± 0.03e	3.92 ± 0.04f	1.06 ± 0.01e	14.23 ± 0.05cd	5.14 ± 0.01f
Lambert	11.37 ± 0.04b	3.78 ± 0.03g	0.97 ± 0.01f	14.12 ± 0.05d	7.78 ± 0.03b

*: Difference between means represented with the same letter in the same column is not significant at 0.05 level.

Table 6. Correlations between phenolic compounds, organic acids, vitamin C and antioxidant activity of sweet cherry fruit

	(V_2)	(V_3)	(V_4)	(V_5)	(V_6)	(V_7)	(V_8)	(V_9)	(V_{10})	(V_{11})	(V_{12})	(V_{13})	(V_{14})	(V_{15})	(V_{16})	(V_{17})	(V_{18})	(V_{19})	(V_{20})	(V_{21})	(V_{22})	(V_{23})	(V_{24})
Protocatechuic (V_1)	-0.83**	-0.51*	-0.05	-0.30	-0.16	-0.21	-0.37	-0.45	0.41	-0.56*	-0.11	0.37	-0.12	0.06	0.79**	0.11	0.37	0.05	-0.21	-0.18	-0.34	0.10	-0.10
Vanillic (V_2)		0.48	-0.43	0.15	0.15	0.51*	0.27	0.57*	-0.30	0.71**	0.39	-0.54*	-0.17	-0.34	-0.63**	0.27	-0.03	0.10	0.35	0.34	0.52*	0.18	-0.09
Ellagic (V_3)			0.04	-0.31	0.42	0.51*	-0.13	0.44	-0.33	0.57*	0.27	-0.17	-0.08	-0.09	-0.44	0.29	0.10	0.24	0.05	0.05	0.51*	0.31	-0.15
Rutin (V_4)				0.32	0.14	-0.54*	-0.22	-0.31	-0.34	-0.51*	-0.51*	0.77**	0.53*	0.14	-0.10	-0.73**	-0.69**	-0.29	-0.30	-0.59*	-0.49	-0.36	0.14
Quercetin (V_5)					-0.34	-0.69**	0.32	-0.30	0.06	-0.49	-0.52*	0.34	0.26	-0.11	-0.06	-0.71**	-0.79**	-0.47	-0.03	-0.24	-0.58*	-0.69**	0.08
Gallic (V_6)						0.21	-0.78**	0.76**	-0.48	0.09	0.01	0.04	0.39	0.04	-0.52*	0.04	-0.06	0.53*	-0.10	-0.53*	-0.07	0.46	0.00
Catechin (V_7)							-0.05	0.49	-0.36	0.88**	0.88**	-0.51*	-0.28	-0.44	-0.27	0.75**	0.65**	0.34	0.28	0.46	0.90**	0.79**	-0.23
Chlorogenic (V_8)								-0.38	0.31	0.31	0.07	-0.46	-0.30	0.15	0.02	0.00	0.00	-0.41	0.20	0.68**	0.30	-0.44	0.15
Caffeic (V_9)									-0.49	0.50*	0.42	-0.43	0.31	-0.16	-0.66**	0.34	0.16	0.70**	-0.09	-0.22	0.31	0.63**	-0.22
Syringic (V_{10})										-0.30	-0.45	-0.19	-0.65**	0.54*	0.67**	0.20	0.31	-0.11	-0.03	0.32	-0.20	-0.52*	0.07
p-coumaric (V_{11})											0.74**	-0.73**	-0.29	-0.20	-0.48	0.64**	0.49	0.24	0.32	0.61*	0.93**	0.52*	-0.09
Ferulic (V_{12})												-0.44	0.00	-0.62**	-0.20	0.61*	0.56*	0.32	0.13	0.37	0.79**	0.84**	-0.34
o-coumaric (V_{13})													0.36	-0.21	0.33	-0.55*	-0.50*	-0.22	-0.38	-0.71**	-0.58*	-0.21	-0.18
Phlorodizin (V_{14})														-0.19	-0.47	-0.59*	-0.56*	0.12	-0.30	-0.66**	-0.42	0.17	0.05
Oxalic (V_{15})															0.10	-0.09	0.03	0.03	-0.12	0.06	-0.25	-0.51*	0.40
Citric (V_{16})																0.24	0.40	-0.01	-0.36	0.01	-0.17	-0.19	-0.36
Malic (V_{17})																	0.94**	0.60*	-0.09	0.41	0.77**	0.60*	-0.50*
Succinic (V_{18})																		0.51*	-0.08	0.44	0.65**	0.57*	-0.37
Fumaric (V_{19})																			-0.64**	-0.37	0.28	0.62**	-0.67**
Glucose (V_{20})																				0.65**	0.16	-0.09	0.74**
Fructose (V_{21})																					0.60*	-0.06	0.34
Sucrose (V_{22})																						0.56*	-0.29
Vitamin C (V_{23})																							-0.42
TEAC (V_{24})																							1

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