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Original Article

Phytochemical and Antioxidant Diversity in Fruits of Currant (*Ribes* spp.)

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Abstract

Currant successfully grown in a wide area in Turkey due to its environmental plasticity. The aim of this study is to determine variations in phytochemical contents and antioxidant capacity from certain currant cultivars and genotypes commercially grown in Turkey. Fruit samples taken from two red currant cultivars ('Red Lake', 'Rovada') and four black ('S. Nigrum', 'Tokat 2', 'Tokat 3' and 'Tokat 4') and the genotype 1310 (red currant) were subjected to analysis for phenolic compounds (protocatechuic, vanillic acid, ellagic acid, rutin, quercetin, gallic acid, catechin, chlorogenic acid, caffeic acid, syringic acid, p-coumaric acid, o-coumaric acid, phloridzin and ferulic acid), organic acids (citric acid, tartaric acid, malic acid, succinic acid, and fumaric acid), vitamin C, antioxidant capacity (Trolox equivalent antioxidant capacity [TEAC] assay) and sugars (glucose, fructose and sucrose). Results showed that phytochemical contents and antioxidant capacities statistically varied among currant cultivars and genotype ($p<0.05$). Caffeic acid was determined only in the genotype 1301. Ellagic acid (1.680 mg/100 g), gallic acid (2.022 mg/100 g), rutin (4.649 mg/100 g), catechin (8.005 mg/100 g) and chlorogenic acid (2.721 mg/100 g) were found the highest values in 'Tokat 3', 'Red Lake', 'Tokat 3', 1310 and 'S. Nigrum', respectively. Citric acid, fumaric acid, and malic acid were dominant among organic acids for all cultivars and the genotype 1310. Contents of glucose and fructose among sugars were measured to be higher than content of sucrose for all cultivars and the genotype. The highest antioxidant capacity was detected in cultivar of 'Rovada' and the genotype 1310.

Keywords: black currant; phenolic compounds; phytochemicals; red currant

Introduction

Fruits are diets high and widely recommended for their health-promoting properties. They historically held a place in dietary guidance because of their high concentrations of vitamins, especially vitamins C and A; minerals, especially electrolytes; and more recently phytochemicals. Fruits are also important source of antioxidant substances and dietary fiber (Kamiloglu *et al*., 2009; Tosun *et al*., 2009; Ercisli *et al*., 2012; Yazici and Sahin, 2016; Zorenc *et al*., 2016).

Currant not only includes several vitamins and nutritional minerals but also has appetizing, digestive, diuretic, anti-inflammatory, and anti-rheumatic properties. Owing to their unique taste, color, and odor, currants are used in many foods such as fruit juice, jam, syrup, marmalade, jelly, candy, cream-cake, ice cream, and dairy products. Like the other berries, currant can support a healthy life by having a protective effect against chronic disorders, cancer, and cardiac diseases by virtue of their phytochemicals (Maatta *et al*., 2010; Milivojevic *et al*., 2012; Mikulic-Petkovsek *et al*., 2015; Mattila *et al*., 2016; Mikulic-Petkovsek *et al*., 2016). Furthermore, currant having numerous phenolics and high antioxidant activity, particularly black currant, has become a crucial tool for functional food industry (Anttonen and Karjalainen, 2006).

Phenolics, which are one of the most significant phytochemical groups commonly forming in plants, are substantially important from physiological and morphological aspects. These compounds play a critical part for development and reproduction and ensuring protection against pathogens and predators as well as contributing to formation of color and sensory properties in fruits and vegetables (Mikulic-Petkovsek *et al*., 2016). Positive effects

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of berry fruits on health are also associated with their phenolic compounds. Beneficial effects provided by these phenolic compounds are based on their antioxidant activity (Heim *et al*., 2002). Berry fruits rich sources of phenolic compound containing anthocyanins, flavonols, ellagitannins, hydroxybenzoic acid, hydroxycinnamic acid, and proanthocyanidins (Maatta *et al*., 2001; Wu *et al*., 2004).

Anthocyanin deficiency in colorless fruits (green and white) was associated with the increasing levels of phenolic acids. Anthocyanins were dominant in black and red currants and also proanthocyanidins and phenolic acids were more dominant in green and white currants (Maatta *et al*., 2001). Studies indicated that numerous berry fruit species are the source of phenolic compound and value of these fruit species has increased with the use of them as raw material in several products and understanding their benefits on human health (Haslam, 1996; Parr and Bolwell, 2000; Maatta-Riihinen *et al*., 2004). Phenolic compounds were reported decreasing free radicals, preventing cancer, strengthening immune system and inhibiting formation of tumor (Zhishen *et al*., 1999; Bermudez-Soto and Tomas-Barberan, 2004). Fruit juice mixture containing some berry fruits also including black currant with high amounts of phenolic compounds particularly anthocyanins (Moyer *et al*., 2002) was reported to lead health protecting effects by both being consumed and used as functional food due to anthocyanins and ascorbic acid (Netzel *et al*., 2002). It was stated that the growing region and weather conditions had an effect on phenolic compound in fruits and differences occurred between cultivars (Dogan *et al*., 2014; Alp *et al*., 2016). All cultivars of black currant growing in regions with high altitude were also determined to have lower contents of total flavonol, total anthocyanin, and total phenolic compound compared to those growing in lowlands. In addition temperature and light exposure caused major changes on composition of phenolic compound (Zheng *et al*., 2012). It was observed that cultivation systems also had an effect on phenolic content and antioxidant capacity and fruits of organically grown currant had higher total phenolic content especially anthocyanins and higher antioxidant activity compared to conventionally grown ones (Anttonen and Karjalainen, 2006; Wojdylo *et al*., 2013). Eyduran and Agaoglu (2007) stated that the most appropriate currant cultivar for climate conditions of Ankara was 'Red Lake'. In a two-year study examining four black currant cultivars ('Titania', 'Triton', 'Tsema' and 'Cacanska Crna') and three red currant cultivars ('Junifer', 'Rolan' and 'Stanza'); anthocyanins were measured to be more dominant in black cultivars compared to red ones. In addition, even though sugars and organic acids were determined to have similar amounts in both species of *Ribes*, vitamin C was three times higher in black currants (Milivojevic *et al*., 2012).

In this study, some red and black currant cultivars growing in Turkey and the genotype 1310 (red currant), which was determined as a result of selection studies, were examined and their phytochemical contents were identified. The fact that the study determines especially anti-carcinogenic phenolic compounds, organic acids, and antioxidant capacities of currant fruits that are essential for human health and are among important quality criteria reveals currency of the study and also the genotype 1310 presenting significant results is also thought to make contributions to breeding studies.

Materials and Methods

Plant material

In this study, four black currant cultivars ('Tokat 2', 'Tokat 3', 'Tokat 4' and 'S. Nigrum'), two red currant cultivars ('Red Lake' and 'Rovada') and one red currant genotype (1310 type) were used. The plants were planted in 1 × 1.5 m intervals in Malatya province in Turkey and the drip irrigation was used.

The fruits were harvested in the last week of June. Harvest was made in periods when fruits of examined cultivars and genotypes completely ripe. Fruit sample of approximately 500 g was taken from each cultivar and genotype. Fruit samples collected homogenously were stored at -80 °C until their laboratory analyses were performed.

Analysis of phenolic acids

Protocatechuic, ellagic acid, gallic acid, catechin, chlorogenic acid, caffeic acid, p-coumaric, o-coumaric, vanillic, rutin, syringic acid, quercetin, phloridzin, and ferulic acids were detected among phenolic acids in currant fruits in accordance with the modified method of Rodriguez-Delgado *et al*. (2001). Fruit extracts were mixed with distilled water at the ratio of 1:1. The mixture was centrifuged for 15 min at 15000 rpm. Supernatants were filtrated with coarse filter paper and twice with 0.45 μm membrane filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA), and injected into an HPLC (Agilent. USA). Chromatographic separation was performed with a 250 × 4.6 mm, 4 μm ODS column (HiChrom, USA). Solvent A methanol: acetic acid: water (10:2:28) and Solvent B methanol: acetic acid: water (90:2:8) were used as the mobile phase. Spectral measurements were made at 254 and 280 nm, and flow rate and injection volume were adjusted to 1 mL/min and 20 μL, respectively.

Analysis of organic acids

Succinic acid, citric acid, malic acid, fumaric acid and tartaric acid composition of the currant berries were identified by Bevilacqua and Califano (1989). Juice extracts were obtained by mashing the berries in cheesecloth, then the samples were stored at -20 °C until they were analyzed. 5 mL of each sample was mixed with 20 ml of 0.009 N H_2SO_4 (Heidolph Silent Crusher M, Germany), and then homogenized for 1 h with a shaker (Heidolph Unimax 1010, Germany). The mixture was centrifuged for 15 min at 15000 rpm, and supernatants were filtrated twice with 0.45 μm membrane filter after filtration with coarse filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA) and run through a SEP-PAK C18 cartridge. Organic acid readings were performed with HPLC using Aminex column (HPX - 87 H, 300 mm × 7.8 mm, Bio-Rad Laboratories, Richmond, CA, USA) at 214 and 280 nm wavelengths, using Agilent packaged software (Agilent, USA).

Analysis of Vitamin C

Vitamin C content was detected based on modified HPLC procedure suggested by Cemeroglu (2007). 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 ° 4.60 mm, 5 µ) was used for identification of ascorbic acid at 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 by 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 (Ozgen *et al*., 2006). For longer stability, the mixture was diluted with 20 mM sodium acetate buffer in acidic pH of 4.5, and read at 734 nm wavelength, 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 wavelength for absorbance detection.

Sugar analysis

The modified method of Melgarejo *et al*. (2000) was used for sugar (glucose, fructose, 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-NH2 column using 85% acetonitrile as liquid phase with refractive index detector (IR). Fructose and glucose standards were used for sugar calculations.

Statistical analyses

Three replicates including 30 fruits per replicate were carried out. Descriptive statistics of phenolic compounds, organic acids, sugars, vitamin C, and antioxidant capacity extracted from cultivars and genotype were represented as mean±SE. Experimental data were evaluated by using analysis of variance ANOVA and significant differences between the means of three replicates ($p<0.005$) were determined by using Duncan's multiple range test in the SPSS 20 for Windows.

Results and Discussion

Phenolic acids

In this study, protocatechuic, vanillic acid, ellagic acid, rutin, quercetin, gallic acid, catechin, chlorogenic acid, caffeic acid, syringic acid, p-coumaric acid, o-coumaric acid, phloridzin, and ferulic acid contents among phenolic compounds varied in all cultivars and genotype (Table 1). Protocatechuic acid content was measured to be the highest in 'S. Nigrum' cultivar (1.422 mg/100 g) and the lowest in genotype 1310 (0.238 mg/100 g). The amount of vanillic acid in currants ranged between 0.390 mg/100 g and 0.078 mg/100 g. The highest ellagic acid content was determined as 1.680 mg/100 g in 'Tokat 3' cultivar, whereas the lowest ellagic acid content was determined as 0.797 mg/100 g in 'Tokat 2'. The rutin content was measured as the highest value (4.649 mg/100 g) in 'Tokat 3' cultivar, the lowest value was found as 1.521 g/100 g in 'Red Lake' cultivar. The highest quercetin content was 0.850 mg/100 g in 'Rovada' cultivar. Gallic acid content was measured between 2.022 mg/100 g and 1.011 mg/100 g amongst the cultivars and genotypes. The highest catechin level was 8.005 mg/100 g in genotype 1310; whereas, the lowest level was 1.920 mg/100 g in 'Tokat 4' cultivar (Table 1). The highest chlorogenic acid content was 2.721 mg/100 g in 'S. Nigrum' cultivar. Caffeic acid content was determined as 0.198 mg/100 g only in genotype 1310. While highest Syringic acid content was obtained from 'Red Lake' and 'Tokat 3' cultivars (0.149 and 0.146 mg/100 g, respectively), the lowest value was 0.073 mg/100 g and determined in 'Rovada' cultivar. The highest p-coumaric acid content was 0.167 mg/100 g and determined in 'Tokat 3' cultivar. The highest o-coumaric acid content was found in 'Rovada' cultivar at the level of 0.177 mg/100 g. The highest phloridzin content was detected as 0.662 mg/100 g in fruits from 'Rovada' cultivar. While the genotype 1310 yielded the best result with 0.605 mg/100 g in terms of ferulic acid content, ferulic acid level was determined between 0.153 mg/100 g and 0.605 mg/100 g among the samples (Table 2).

Hakkinen *et al*. (1999) used 19 berry fruits and determined that quercetin, p-coumaric acid, caffeic acid,

Table 1. Protocatechuic acid, vanillic acid, ellagic acid, rutin, quercetin, gallic acid, and catechin contents (mg/100 g) of currant cultivars and genotype

Cultivars and genotype	Protocatechuic acid	Vanillic acid	Ellagic acid	Rutin	Quercetin	Gallic acid	Catechin
Red Lake	0.349±0.001 d	ND	0.950±0.128 c	1.521±0.015 f	0.635±0.006 b	2.022±0.008 a	6.258±0.232 b
Rovada	0.723±0.007 c	ND	0.910±0.197 c	2.073±0.008 d	0.850±0.003 a	1.470±0.010 b	3.881±0.068 c
S. Nigrum	1.422±0.008 a	ND	0.934±0.030 c	2.837±0.011 c	0.124±0.001 f	0.309±0.008 e	3.548±0.032 c
Tokat 2	0.831±0.009 b	0.078±0.002 c	0.797±0.115 c	3.221±0.011 b	0.122±0.003 f	0.681±0.009 d	3.456±0.036 c
Tokat 3	0.860±0.006 b	0.390±0.009 a	1.680±0.091 a	4.649±0.007 a	0.147±0.002 e	1.011±0.009 c	2.709±0.033 d
Tokat 4	0.851±0.049 b	ND	1.301±0.033 b	1.829±0.013 e	0.159±0.004 d	0.136±0.004 g	1.920±0.025 e
1310	0.238±0.004 e	0.173±0.005 b	0.899±0.011 c	2.841±0.007 c	0.527±0.008 c	0.201±0.002 f	8.005±0.600 a

**: Difference between means represented with the different letter in the same column is significant at 0.05 level. ND: Not detected.

Table 2. Chlorogenic acid, caffeic acid, syringic acid, p coumaric, o coumaric, phloridzin, and ferulic acid contents (mg/100 g) of currant cultivars and genotype

Cultivars and genotype	Chlorogenic acid	Caffeic acid	Syringic acid	*p* Coumaric	*o* Coumaric	Phloridzin	Ferulic acid
Red Lake	1.705±0.009 d	ND	0.149±0.001 a	0.080±0.001 e	0.068±0.001 e	0.349±0.002 c	0.234±0.002 b
Rovada	1.544±0.008 e	ND	0.073±0.001 d	0.071±0.004 f	0.177±0.001 a	0.662±0.020 a	0.153±0.005 e
S. Nigrum	2.721±0.057 a	ND	0.119±0.004 c	0.151±0.004 b	0.065±0.001 ef	0.456±0.010 b	0.199±0.001 c
Tokat 2	2.372±0.011 b	ND	0.132±0.002 b	0.149±0.000 b	0.098±0.001 d	0.269±0.009 e	0.175±0.001 d
Tokat 3	0.798±0.003 f	ND	0.146±0.000 a	0.167±0.001 a	0.061±0.001 f	0.261±0.004 e	0.203±0.001 c
Tokat 4	1.850±0.006 c	ND	0.122±0.003 c	0.128±0.001 d	0.162±0.004 b	0.207±0.003 f	0.174±0.002 d
1310	0.394±0.008 g	0.198±0.001 a	0.118±0.004 c	0.142±0.002 c	0.110±0.001 c	0.320±0.001 d	0.605±0.005 a

*: Difference between means represented with the different letter in the same column is significant at 0.05 level. ND: Not detected.

ferulic acid and ellagic acid contents in currant (black, red, white, and green) samples were in the range of 10.1-39.6%, 12.1-41.2%, 16.1-34.0%, 3.1-5.4%, and 2.3-8.2%; respectively. Maatta-Riihinen *et al*. (2004) measured p-coumaric acid content as 39, 60, 11, and 31 mg/kg respectively and quercetin content as 50, 33, 4, and 12 mg/kg respectively in black, green, red, and white currants. Borges *et al*. (2010) determined that the amount of chlorogenic acid contained by black and red currants among berry fruits were 80 and 89 nmol/g, respectively. As a result of analyses made in fruits of 'Rovada' and 'Rosenthal' currant cultivars, it was found that rutin content was between 1.89-4.24 mg/100 g and 0.47-4.58 mg/100 g respectively, catechin content was 7.49 mg/100 g in 'Rosenthal' cultivar and between 0.77-5.07 mg/100 g in 'Rovada' cultivar, chlorogenic acid content was 0.79 mg/100 g in 'Rosenthal' cultivar and 0.97 mg/100 g in 'Rovada' cultivar, p-coumaric acid content was 0.91 mg/100 g in 'Rosenthal' cultivar and 0.97 mg/100 g for 'Rovada' cultivar, and ferulic acid content was 0.63 mg/100 g in 'Rosenthal' cultivar and 0.71 mg/100 g in 'Rovada' cultivar (Gavrilova *et al*. 2011).

Organic acids

Organic acids are phytochemicals flavoring fruits and being critical in terms of human health. Previous studies revealed that organic acids, particularly malic acid, citric acid, and tartaric acid had significant contributions to health in several aspects such as strengthening immune system, preventing formation of kidney stones, relieving mouth sores, reducing risk of toxic metal poisoning, protecting beauty of skin, and decreasing fibromyalgia symptoms (Abraham and Flechas, 1992; Penniston *et al*., 2007). In this study, there were differences between cultivars and genotype in terms of organic acid contents (Table 3). Citric acid, fumaric acid, and malic acid among organic acids were determined to have the highest value in all currant cultivars and genotype. These were followed by tartaric acid and succinic acid. While 'Rovada' cultivar had the best value with 20.20 g/kg in citric acid content, the genotype 1310 gave the lowest value with 12.25 g/kg. The highest tartaric acid content was measured as 1.64 g/kg in 'Rovada' cultivar. The genotype 1310 gave the highest value as 9.22 g/kg in terms of malic acid content; whereas, 'Red Lake' cultivar had the lowest value as 1.24 g/kg. 'Tokat 2' cultivar was determined to have the highest succinic acid content (2.08 g/kg). The highest fumaric acid content was determined in 'Tokat 3' cultivar (Table 3). Zheng *et al*. (2009) determined malic acid and citric acid contents of white, green, and red currants as 3.4-10.5 and 16.1-25.7 g/L, respectively. According to results of their two-year trial, Milivojevic *et al*. (2012) measured citric acid, malic acid and tartaric acid contents of black currants as 5.7-7.2 g/kg, 1.9-5.1 g/kg and 0.2-0.5 g/kg respectively in the first year,; on the other hand, they determined citric acid, malic acid and tartaric acid contents of black currants as 9.3-11.7 g/kg, 2.4-7.3 g/kg and 0.5-1.2 g/kg respectively in the second year. In addition, citric acid, malic acid, and tartaric acid contents of red currants were determined between 5.8-9.8 g/kg, 2.9-3.8 g/kg and 0.3-0.9 g/kg respectively in the first year; whereas, citric acid, malic acid and tartaric acid contents of red currants were determined between 9.6-14.7 g/kg, 2.6-5.8 g/kg and 0.3-0.4 g/kg respectively in the second year. Organic acid contents may emerge at different levels due to genetic factors, cultural applications, climate conditions, and soil structure (Celik *et al*., 2007; Hegedus *et al*., 2010).

Vitamin C

Differences were observed between cultivars and genotype in terms of vitamin C content (Table 4). The highest vitamin C content was measured as 126.51 mg/100 g in 'Tokat 2' cultivar, the lowest value was obtained as 14.94 mg/100 g in genotype 1310. Zheng *et al*. (2009) measured vitamin C content as 0.22 and 1.07 g/L in currants. Karacali (2012) stated that fruit species could be classified within three groups that are poor, moderate, and rich in vitamin C contents. In this regard, currant fruits are involved in the group rich in vitamin C contents. 'Tokat 2' cultivar from cultivars used in this study was determined to be rich in vitamin C with 126.51 mg/100 g. Borges *et al*. (2010) measured vitamin C contents of black and red currants as 2328 and 313 nmol/g. In the study conducted by Milivojevic *et al*. (2012) on black and red currants in 2008 and 2009; they determined that vitamin C content was between 147.8-202.3 and 117.8-175.0 mg/100 g for black currants and 35.2-45.8 mg/100 g for white currants, respectively.

Table 3. Citric acid, tartaric acid, malic acid, succinic acid, and fumaric acid contents in currant cultivars and genotype

Cultivars and genotype	Citric acid	Tartaric acid	Malic acid	Succinic acid	Fumaric acid
Red Lake	15.07±0.07 d	0.95±0.03 c	1.24±0.04 g	0.73±0.01 d	7.19±0.07 f
Rovada	20.20±0.07 a	1.64±0.06 a	1.49±0.03 f	1.41±0.02 c	8.52±0.04 e
S. Nigrum	12.62±0.06 e	0.91±0.03 c	2.30±0.08 e	2.02±0.05 a	12.80±0.10 b
Tokat 2	16.13±0.13 b	1.07±0.06 b	4.11±0.06 b	2.08±0.10 a	12.60±0.13 c
Tokat 3	12.31±0.07 f	0.66±0.01 d	3.24±0.06 d	1.82±0.01 b	14.60±0.06 a
Tokat 4	15.86±0.05 c	0.74±0.02 d	3.74±0.03 c	2.00±0.03 a	8.80±0.07 d
1310	12.25±0.04 f	0.65±0.02 d	9.22±0.05 a	0.25±0.01 e	6.56±0.07 g

*: Difference between means represented with the different letter in the same column is significant at 0.05 level.

Table 4. Vitamin C, total antioxidant capacity (TEAC), and sugar contents in currant cultivars and genotype

Cultivars and genotype	Vitamin C	TEAC	Glucose	Fructose	Sucrose
Red Lake	52.93±0.04 e	35.03±0.13 d	31.18±0.10 b	16.23±0.08 a	1.36±0.04 b
Rovada	46.62±0.11 f	41.29±0.75 a	24.37±0.27 d	12.25±0.11 c	1.03±0.02 d
S. Nigrum	99.47±0.24 d	39.11±0.10 b	34.23±0.08 a	15.19±0.08 b	2.21±0.04 a
Tokat 2	126.51±1.02 a	33.11±0.06 e	20.99±0.30 e	11.23±0.16 d	1.14±0.04 c
Tokat 3	108.76±0.34 b	38.20±0.92 c	19.32±0.19 f	11.20±0.14 d	0.96±0.01 e
Tokat 4	104.46±0.02 c	40.72±0.10 a	26.13±0.01 c	15.09±0.12 b	1.77±0.02 c
1310	14.94±0.13 g	41.27±0.17 a	17.21±0.08 g	8.53±0.04 e	0.90±0.00 e

*: Difference between means represented with the different letter in the same column is significant at 0.05 level.

Antioxidant activity

As shown in Table 4, differences were observed between cultivars and genotype in terms of total antioxidant capacity (TEAC) ($p<0.05$). Accordingly; the highest total antioxidant capacity was determined to be 41.29 μmolTE/g in 'Rovada' cultivar; whereas, the lowest total antioxidant capacity was 33.11 μmolTE/g in 'Tokat 2' cultivar (Table 4). In a study examining some berry fruit species, total antioxidant activity of black and red currants was measured as 51.6 and 24.6 μmol of Fe2+/g, respectively (Borges *et al*., 2010).

Sugars

In this study, contents of glucose, fructose, and sucrose among basic sugars in currant fruits were determined and differences between cultivars and genotype in terms of these sugar contents were revealed (Table 4). Sucrose content was measured to be lower than other sugars. Additionally, the highest sucrose content was obtained as 2.21 g/kg from 'S. Nigrum' cultivar. While the highest value of glucose content was obtained to be 34.23 g/kg in 'S. Nigrum' cultivar, the lowest value was 17.21 g/kg in genotype 1310. The highest fructose value was measured as 16.23 g/kg in 'Red Lake' cultivar. Zheng *et al*. (2009) evaluated amounts of glucose, fructose, and sucrose in currant fruits and they determined the amount of fructose and glucose between 38.7-45.7 g/L and 31.1-43.8 g/L. Milivojevic *et al*. (2012) worked on black and red currants and they found that black cultivars had fructose content between 16.4-40.9 and 18.3-34.2 g/kg, and white cultivars had fructose content between 30.3-40.2 and 20.8-26.0 g/kg; glucose content between 21.4-78.9 and 14.4-24.9 g/kg in black cultivars, and between 44.3-86.8 and 16.8-24.5 g/kg in white cultivars; sucrose content was between 1.8-4.1 and 1.0-7.8 g/kg in black cultivars and between 1.5-1.7 and 0.5-1.8 g/kg in white cultivars, respectively.

Conclusions

In this study, currants were grown under the same ecologic conditions and same cultural applications, thus genetic base had an effect on biochemical contents of fruits and these differences were statistically significant ($p<0.05$). In the study, standard currant cultivars and the genotype were observed to be rich in phenolic compound particularly chlorogenic acid, catechin, rutin, ellagic acid and protocatechuic having anti-carcinogenic, anti-fungal, and antimicrobial properties. In addition, it will be beneficial to consider the genotype 1310 having superior traits in biochemical content and coming to the fore especially in terms of catechin, caffeic acid, ferulic acid, malic acid, and total antioxidant capacity which important for breeding

new cultivars. Results obtained from the present study are thought to be a source for further research and to have importance in terms of revealing the actual value of world's germplasms.

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