



Antioxidant Activity and Biochemical Compounds of *Vitis vinifera* L. (cv. 'Katikara') and *Vitis labrusca* L. (cv. 'Isabella') Grown in Black Sea Coast of Turkey

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Abstract

The antioxidant activity and phenolic compounds content of pomace from the berries of 'Isabella' and 'Katikara' grape varieties widely produced in the Eastern Black Sea region of Turkey were researched for use as a potential natural antioxidant source. The results of this study indicated that there were statistically significant differences ($p < 0.05$) between two varieties for some biochemical compounds. There are high positive correlations among antioxidant activity, phenolic compounds and 'Isabella'. Similarly, catechin, citric acid, epicatechin, tartaric acid, total phenolic, vitamin C, gallic acid and *p*-coumaric acid are strongly and positively correlated with each other. It was observed that 'Isabella' grapes presented higher antioxidant potential with relating presence of high content of phenolic compounds. Mineral elements, which are of great importance for cell protection and healthy teeth, bone and skin structure, were found widely in the 'Katikara' variety. As a result, we can concluded that consuming these two grape varieties will provide significant benefits in blood pressure, heart rhythm, muscle functions, protection of fluid balance in the body, reproduction and many other functions in the human body.

Keywords Antioxidant activity · Grape pomace and juice · Phenolic compounds · Vitis

Antioxidative Aktivität und biochemische Verbindungen von *Vitis vinifera* L. ('Katikara') und *Vitis labrusca* L. (vgl. 'Isabella') im Anbau an der türkischen Schwarzmeerküste

Schlüsselwörter Antioxidative Aktivität · Trester und Saft · Phenolverbindungen · Vitis

Introduction

Grapes (*Vitis* sp.) are among the most grown fruits around the world (Kaya 2019; 2020), and their properties and compositions have been extensively reported with various studies on the presence of large amounts of phenolic compounds (Rockenbach et al. 2011; Burin et al. 2014; Ribeiro et al. 2015; Gökçen et al. 2017; Canturk et al. 2018). In addition, grapes with one of the highest phenolic compound contents are among the most consumed fruits throughout the world in their processed or natural form (Manach et al. 2005). Be-

sides that grape intake is crucial to health, and consumption of their derivatives has been associated with the prevention of cancer (Nandakumar et al. 2008) and Alzheimer's diseases (Anastasiadi et al. 2010), as well as cardiovascular diseases due to inhibition of the oxidation of low-density lipoproteins (Frankel et al. 1995). Grape, which is also effective in the treatment of some liver diseases and anemia, regulates the functioning of the kidney and intestinal system without harming the stomach due to the fruit acids and fibrous structure it contains, and helps to clean the blood (Çelik et al. 1998).

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Turkey, which is the world's sixth largest grape-producing, annually produces approximately 4.2 million tons of grapes, and considered to be one of the most favorable countries for grape production in terms of soil and climatic conditions (Uzun and Bayır 2008; FAOSTAT 2018). Indeed, grape cultivation can be carried out in many regions of the Turkey, while *V. labrusca* (e.g., 'Isabella' cultivar) are particularly grown in moist areas at the coastline of the Eastern Black Sea region (Çelik 2001). This cultivar displays low susceptibility to major fungal diseases that are known to attack the vine and a high production capacity (Lago-Vanzela et al. 2011). On the other hand, although *V. vinifera* grape production in the Eastern Black Sea region of Turkey, particularly the variety 'Katıkara', has been increasing in recent years, these grapes still represent a small proportion of the national production in the region. Most of the data in the literature on the phenolic composition of wines and grapes are related to traditional wine producing countries (especially, in Europe and North America), and the grapes studies are predominant (*Vitis vinifera* L.) wine grapes (Mazzuca et al. 2005; Burin et al. 2014). In Turkey, however, there is little information on the organic acids, phenolic compounds, the antioxidant activity of 'Isabella' and 'Katıkara' grape varieties and their mineral contents reported in the literature.

Considering that there is limited information available on organic acids, phenolics compounds, antioxidant activity and mineral contents of grape juice and other local consumption products such as sausage, vinegar, kofte, pekmez produced from 'Isabella' and 'Katıkara' grape varieties in Eastern Black Sea region of Turkey, providing more data on this parameter would be useful for evaluating the potential biological effects of these products. In this regard, the objective of this study was to analyze berry pomace of two grape varieties, 'Isabella' (*Vitis labrusca* L.), 'Katıkara' (*Vitis vinifera* L.) widely produced in Ordu province, Turkey, in terms of organic acids, phenolic compounds, antioxidant activity and mineral contents.

Material and Method

Chemicals

Chemicals were obtained from Sigma-Aldrich (St. Louis, Missouri, USA).

Samples

In the study, *V. vinifera* L. cv. 'Katıkara' and *V. labrusca* L. cv. 'Isabella' was manually harvested on Black Sea coast of Ordu province. The berries of the clones were harvested from randomly selected vines at around 19% soluble solid

in the vintage of 2017 seasons. Nine batches of grape clusters obtained from cultivars were sampled following a zigzag path between two marked rows of vines in three different zones of the vineyard. Once in the lab, grape berries from each batch were randomly separated by picking berries from the bottom, central, and top parts of every cluster. The picked grapes were bulked and each grape sub-sample was used for all the different classes of analysis, which were made in triplicate for each one. The results were given as the average of the data obtained for all the grape batches ($n=3$).

Detection of Antioxidant Capacity (as Trolox Equivalents)

2,2-Azino- Bis-3- thylbenzothiazoline-6-Sulfonic Acid (ABTS) acetate was solved in a buffer for a standard antioxidant capacity (TA) measurement, and then, $K_2S_2O_8$ (potassium persulphate) was prepared (Ozgen et al. 2006). The stability of the mixture was maintained for a long time by dissolving 20mM sodium acetate buffer solution at acidic pH 4.5 and 734nm with an absorbance of 0.700 ± 0.01 . For spectrophotometric evaluations of samples, 3ml of the ABTS+ solution was mixed with 20 μ l of fruit extract and then incubated for 10min. Absorbance values were obtained at 734nm in spectrometry readings and the results were expressed as Trolox equivalents (μ mol TEAC/100g of grape berries).

Detection and Extraction of Phenolic Acids

Ten phenolic compounds (protocatechuic acid, gallic acid, *p*-coumaric acid, vanillic acid, rutin, syringic acid, (+) -catechin, (–) -epicatechin, quercetin and *trans*-resveratrol) as phenolic acids were identified. The phenolic compounds of grape cultivars were identified by HPLC using the modified method of Rodriguez-Delgado et al. (2001). The grape berry samples mixed with distilled water at a ratio of 1:1 were centrifuged at 15000rpm for 15min. And then, the upper part was filtered with 0.45 μ m mil porous filters and injected into the HPLC. Chromatography assays were determined by Agilent 1100 (Agilent) HPLC device by using a DAD detector (Agilent, USA) and 4 μ m ODS column, 250 $\times$ 4.6mm (HiChrom, USA). A methanol:water:acetic acid (10:28:2) and B methanol:water:acetic acid (90:8:2) were utilized for a mobile phase. The extraction in the samples was occurred at 254 and 280nm, 20 μ L injection volume and 1 ml/min flow rate.

Analysis of Ascorbic Acid (Vitamin C)

The specimen of 5g from the whole berries was transferred to centrifuge tubes. After that 5ml 2.5% M-phosphoric acid

solution was added on test tube. The mixture in test tubes was centrifuged with 6500 g at 4 °C for 10 min. 0.5 ml of the clear part of the supernatant in the test tube was taken and the 2.5% M-phosphoric solution was added until it reached 10 ml. This new mixture was filtered with 0.45 µm teflon filter and injected into the HPLC. Ascorbic acid (Vitamin C) was determined by the C18 column (Phenomenex Luna C18, 5 µ, 4.60×250 mm) in the HPLC. In particular, ultra-distilled water was used as a mobile phase at a flow rate of 1 ml/min and adjusted to pH 2.2 with H₂SO₄. DAD detector with 254 nm wavelength was utilized for the readings in the samples. For the ascorbic acid determination, different concentration levels of L-ascorbic acid (SigmaA5960) (50, 100, 500, 1000 and 2000 ppm) were utilized (Cemeroglu 2007).

Detection and Extraction of Organic Acids

Samples obtained from berries were stored at −20 °C until processed. Three main organic acids (tartaric, malic, and citric acids) were determined and they were extracted after the method suggested by Bevilacqua and Califano (1989) was modified. 5 g from the whole berry samples were transferred to centrifuge tubes. Then, 20 ml of 0.009 N H₂SO₄ was pureed on the berry samples and homogenized. (Heidolph Silent Crusher M, Germany). Those berry samples were mixed for 1 h on a shaker (Heidolph Unimax 1010, Germany) and then centrifuged at 15,000 rpm for 15 min. The watery parts of the samples extracted from the centrifuge were distilled once through filter paper and then twice through a 0.45 µm membrane filter and finally distilled through the SEP-PAK C18. Organic acids were defined as 3 replications by HPLC (High Performance Liquid Chromatography) according to the method of Bevilacqua and Califano (1989). In the HPLC system used in the determination of organic acids, Aminex HPX-87H, 300 mm×7.8 mm column (Bio-Rad Laboratories, Richmond, CA, ABD), was preferred, and the HPLC tool was commanded by using Agilent program. The DAD detector (Agilent, USA) in the system was tuned to 214 and 280 nm wavelengths.

Mineral Element Analysis

To determine the mineral concentrations in the berries of grape cultivars, samples were oven-dried for 48 h at 68 °C and then ground. A Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Königswinter, Germany). Microelements (Zn, Fe, Cl, Se and B) and macro-(K, P, Mg, Ca and Na) were determined utilizing an inductively coupled plasma spectrophotometer (Optima 2100 DV; Perkin-Elmer, Shelton, CT) (Mertens 2005).

Statistical Analysis

Both univariate and multivariate statistical techniques were used for data analyses. Descriptive statistics were presented as 'mean±standard deviation' for the studied characteristics. Mann-Whitney U test was performed to compare two varieties in terms of phenolic compounds and minerals. Categorical Principal Component Analysis was also performed to determine the relationships among the characteristics as well as to dimension reduction.

Results and Discussion

Antioxidant Activity of Grape Pomace from *V. labrusca* and *V. vinifera* Varieties

Many studies have indicated that natural antioxidants such as vitamin E, vitamin C, flavonoids and polyphenols are functional compounds that prevent free radical damage (Shahidi 2004; Çelik 2001; Sabir et al. 2010). Owing to high levels of antioxidant, anti-inflammatory, anticarcinogenic and antibacterial activities, grape could be used as an effective scavenger of several reactive oxygen species (Burin et al. 2014). Most of the data available in the literature regarding the antioxidative capacity of grapes have focused on the influence of the grape on chronic diseases, including coronary heart disease, cancer, atherosclerosis and diabetes (Bagchi et al. 2000; Gris et al. 2011; Burin et al. 2014). Therefore, the grape has been propagated as a polyphenol-rich food with health beneficial effects owing to its high antioxidative capacity, thus is being usually referred as super fruit (Chang et al. 2018). In our study, there are statistically significant differences between two varieties for the antioxidant activity (Table 1). 'Isabella' (*V. labrusca*) variety was outstanding with its markedly higher antioxidant activity and its values 187.960 µmol TEAC/100 g FW. In contrast, the antioxidant activity of 'Katkara' (*V. vinifera*) (123.705 µmol TEAC/100 g FW) was substantially lower than the other variety. The overall range of the antioxidant activity across the varieties conforms to literature investigations revealed by various researchers using different *V. vinifera* and *V. labrusca* grapes (Lago-Vanzela et al. 2011; Burin et al. 2014).

It is well known that the antioxidant activity of products derived from grapes is influenced not only by their phenolic composition, but also by the total polyphenol content; both of these were mainly influenced by the grape varieties, which was also confirmed in this study. The contribution of basic phenolic components to the antioxidant activity of grapes was investigated by statistical analysis. In general, positive correlations were observed between the antioxidant activity and phenolic compounds in this study. Visualiza-

tion of the phenolic compounds and varieties in two dimensional map is presented in Fig. 1. There are particularly high positive correlations among these phenolic compounds, antioxidant activity and 'Isabella' (Fig. 1). These results are similar to the results of other authors who confirmed that the antioxidant capacity of wine and grapes is related to their phenolic composition (Tagliazucchi et al. 2010; Burin et al. 2014). Contrary to our findings some authors have observed a negative correlation between polyphenol content and antioxidant activity (Nixdorf and Hermosín-Gutiérrez 2010).

Phenolic Acids of Grape Pomace from *V. labrusca* and *V. vinifera* Varieties

There were significant differences between the total content of phenolic compounds in the extracts of two cultivars analyzed (Table 1). This is to be expected as the phenolic concentration in grapes varies depending on cultural, environmental and genetic characteristics (Doshi et al. 2006). 'Isabella' has higher value than that of 'Katikara' for all phenolic compounds, except for protocatechuic acid (Table 1). Sánchez-Alonso et al. (2008) evaluated the total polyphenol content and obtained 78.5 mg/g and obtained 78.5 mg/g in the grape pomace of the 'Airén' grape cultivar in Spain. This value is higher than the results obtained for both grape cultivars the present study. Bozan et al. (2008) found 105.7 and 103.7 mg/g of total phenolic contents in grape seeds of 'Merlot' and 'Cabernet Sauvignon', respectively. On the other hand, the average value of the total phenolic content ranged from 49.3 to 50.41 mg/g (on a dw basis) for seven red grape varieties grown in Turkey (Yemis et al. 2008). The total phenolic content of these grapes is higher than that of both grape cultivars in our study.

Catechin, which is considered a powerful antioxidant, was determined at a higher rate, especially in 'Isabella' (195.215 µg/100 g FW) than in 'Katikara' (83.460 µg/100 g FW) in the present study. It has been reported that the catechin content of the 'Isabella' grape variety widely grown in Brazil was determined as 215.6 µg/100 g. Our findings are in agreement with other studies that also found the concentration of catechin in their study on one *V. labrusca* ('Isabel' grapes) cultivated in the Brazil (Lago-Vanzela et al. 2011). However, the catechin content of the 'Katikara' was determined approximately twice as low as the 'Isabella'. Breksa et al. (2010) reported that the catechin contents varied widely (1.8 to 209.1 µg/g) for 16 raisins (*Vitis vinifera* L.) varieties. The catechin content of the 'Katikara' is among the values specified in the study results.

Given the trans-resveratrol content of the analyzed grapes, this compound was found remarkable concentrations for the two varieties (46.820 µg/g FW for 'Isabella' and 39.425 µg/g FW 'Katikara'; 46.820 µg/g FW and for

'Katikara'; 39.425 µg/g FW), and as previously described (Guerrero et al. 2010), *V. labrusca* grape varieties showed higher concentrations than that of *V. vinifera* grapes. Indeed, the amount of trans-resveratrol found in the 'Isabella' grape suggests that this could be well-considered a grape variety that is a high resveratrol producer, but, successive vintages are required and additional data for other grape samples from different vineyards. In studies compatible with our findings, in this context, it has been reported that *V. vinifera* contains low levels of stress metabolites (resveratrol) compared to other subspecies such as *V. labrusca*, *Vitis rotundifolia* and *Vitis rupestris* (Bonomelli et al. 2004). As to the results performed in quercetin, there were no significant differences between 'Katikara' (146.835 µg/100 g FW) and 'Isabella' (153.990 µg/100 g FW). The vanillic acid content was similar in the 'Katikara' (121.955 µg/100 g FW) and 'Isabella' (116.400 µg/100 g FW). 'Isabella' was superior to the 'Katikara' for syringic acid, gallic acid, (+)-epicatechin and p-coumaric (Table 1). In the previous studies it was reported that gallic acid contents of two genotypes (A95-27 and A95-15) among 16 raisin grape (*V. vinifera* L.) varieties were identified as 24.5 and 6.9 µg/g, respectively (Breksa et al. 2010). Our current results are considerably higher than those reported in this study. In addition, experimental data reported from previous studies have shown that catechins can prevent chronic diseases in humans. Epicatechin and catechin have been shown to be potent inhibitors of human LDL oxidation *in-vitro* conditions (Teissedre et al. 1996). Another study reported a strong inverse relationship between (–)—epicatechin (+)—catechin intake and death from coronary heart disease (Arts et al. 2001a). Similarly, catechins from tea or other sources have been reported to reduce the risk of death from ischemic heart disease (Arts et al. 2001b).

Ascorbic Acid (Vitamin C) of Grape Pomace from *V. labrusca* and *V. vinifera* Varieties

In the study, vitamin C was determined as 6.385 mg in 100 g FW for 'Katikara' and 12.830 mg in 100 g FW for 'Isabella' (Table 1). Santana et al. (2008) reported that the vitamin C content of *Vitis* grapes in Brazil ranged from 17.92 to 4.6 mg 100 g⁻¹ in the total grape juice. Our current findings are consistent with the research results. However, it is known that the contribution of vitamin C to the antioxidant value of fruit extracts/pulps varies greatly from fruit to fruit (Santos et al. 2014). The findings clearly showed that the highest content was determined for average vitamin C as an indicator of the dietary of foods in 'Isabella'.

Table 1 Total phenolic (mg GAE/100 g FW), total antioxidant activity ($\mu\text{mol TEAC}/100\text{ g FW}$), organic acids (g/L), vitamin C (mg/100 g FW), phenolic acids ($\mu\text{g}/100\text{ g FW}$) and mineral elements (mg/kg) of extracts of grape pomace and juice (*Vitis vinifera* L. and *Vitis labrusca* L.)

Measurement parameters	'Isabella' Mean $\pm$ SEM	'Katikara' Mean $\pm$ SEM	<i>P</i> value
Total phenolics	47.560 $\pm$ 2.280	37.045 $\pm$ 1.125	0.054
Total antioxidant activity	187.960 $\pm$ 4.190	123.705 $\pm$ 0.825	0.004
Tartaric acid	3.970 $\pm$ 0.010	2.695 $\pm$ 0.015	0.001
Malic acid	2.720 $\pm$ 0.030	2.480 $\pm$ 0.040	0.041
Citric acid	0.365 $\pm$ 0.015	0.250 $\pm$ 0.010	0.024
Vitamin C	12.830 $\pm$ 0.720	6.385 $\pm$ 0.055	0.012
Protocatechuic acid	24.115 $\pm$ 1.245	69.325 $\pm$ 0.885	0.010
Vanillic acid	116.400 $\pm$ 0.760	121.955 $\pm$ 1.615	0.090
Syringic acid	92.275 $\pm$ 0.395	29.055 $\pm$ 0.395	0.001
(+)-Catechin	195.215 $\pm$ 2.095	83.460 $\pm$ 2.260	0.001
(+)-Epicatechin	188.635 $\pm$ 1.715	125.455 $\pm$ 0.945	0.001
<i>p</i> -coumaric	249.750 $\pm$ 0.890	232.865 $\pm$ 2.385	0.022
Quercetin	153.990 $\pm$ 2.130	146.835 $\pm$ 1.485	0.110
Gallic acid	30.900 $\pm$ 0.280	19.300 $\pm$ 0.960	0.007
<i>Trans</i> -Resveratrol	46.820 $\pm$ 1.460	39.425 $\pm$ 1.305	0.064
P	156.015 $\pm$ 1.165	168.250 $\pm$ 0.930	0.015
K	1495.850 $\pm$ 16.59	1820.715 $\pm$ 3.355	0.003
Ca	207.380 $\pm$ 11.50	314.665 $\pm$ 4.515	0.013
Mg	60.980 $\pm$ 1.820	90.570 $\pm$ 1.710	0.007
Fe	5.180 $\pm$ 0.020	6.255 $\pm$ 0.065	0.004
Mn	0.167 $\pm$ 0.003	0.685 $\pm$ 0.055	0.011
Cu	0.203 $\pm$ 0.005	0.200 $\pm$ 0.050	0.965
Zn	3.330 $\pm$ 0.070	2.085 $\pm$ 0.095	0.009
B	0.026 $\pm$ 0.002	0.059 $\pm$ 0.001	0.005
Si	15.600 $\pm$ 0.190	15.315 $\pm$ 0.405	0.589

Organic Acids of Grape Juices from *V. labrusca* and *V. vinifera* Varieties

The present study results for organic acids are summarized in Table 1. There were no differences in 'Katikara' and 'Isabella' in terms of citric and malic acid contents, except for tartaric acid. Thus, it can be noted that the varieties were not a very significant source of the variation for these two organic acids. Citric acid amount has been reported between 0.2 and 3.0 g/L in unfermented grapes (Amerine and Ough 1980). In our findings, highest citric acid content of varieties was higher than the minimum value of the literature. It has also been found that malic acid varied between 1.43 to 3.40 g/L in different grape cultivars (Escobal et al. 1998; Soyer et al. 2003), and our result is in agreement with those reported by those authors. Tartaric acid, on the other hand, is the most abundant organic acid in grapes and constitutes 40–80% of the total acidity in grapes (Ribéreau-Gayon et al. 2006). Although it is reported that it varies be-

tween 2 and 15 g/L depending on the varieties, temperature, ripening time, and region, it is generally found around 6 g/L (Palma and Barrosa 2002; Keskin et al. 2013). Indeed, it was determined that the tartaric acid content in fresh grape juices of 11 different white grape varieties varied between 4.98 and 7.48 g/L (Soyer et al. 2003). Sabir et al. (2010) has reported that the tartaric acid content of the 'Muscat of Alexandria', 'Italia', 'Isabella', 'Muscat of Hamburg' and 'Alphonse Lavellee' grape cultivars are 5.0, 4.8, 5.2, 4.2 and 3.8 g/L, respectively. In our study, tartaric acid content determined for both grape varieties theare consistent with previous finding in the literature.

In addition, categorical Principal Component Analysis (CATPCA) was performed to determine the relationships among the phenolic compounds and antioxidant activity as well as to dimension reduction. Visualization of the phenolic compounds and varieties of the two dimensional map is presented in Fig. 1. As seen in Fig. 1; quercetin, malic acid, t-resveratrol and citric acid as well as antioxidant activity and 'Isabella' are located in the upper-right region of the map. There are high positive correlations among these phenolic compounds, antioxidant activity and 'Isabella'. Similarly, citric acid, epicatechin, tartaric acid, catechin, vitamin C, total phenolics, gallic acid and *p*-coumaric acid is strongly and positively correlated with each other's as well as the characteristics in which upper-right region. Only protocatechuic acid is located on the lower-left region of the map. Vanillic acid is grouped with 'Katikara' on the upper-left region of the map. According to the first dimension which accounts for 94.01% of the variation, 'Katikara' is strongly and negatively correlated with 'Isabella' for the considered characteristics. Similarly, vanillic and protocatechuic acids are highly and negatively correlated with the other characteristics for the first dimension. These two acids are also negatively correlated with each other for the second dimension which accounts for only 4.21% of the variation. Thus, it can be stated that 'Katikara' is likely to be appropriate for higher vanillic and protocatechuic acid values. However, 'Isabella' can be considered as higher values of the other characteristics.

Mineral Elements of Grape Pomace from *V. labrusca* and *V. vinifera* Varieties

In our study has been detected macro- (P, K, Ca, Mg and Na) and microelements (Fe, Zn, Cl, B and Si). There were significant differences between the varieties in terms of minerals, except for Cu and Si minerals. The results of the mineral analysis showed that the berries of variety 'Katikara' had the biggest amount of K (1820.715 mg kg⁻¹), Ca (314.665 mg kg⁻¹), P (168.250 mg kg⁻¹) and Mg (90.570 mg kg⁻¹) when compared to the 'Isabella' (Table 1). It has been reported that these minerals are necessary for

Fig. 1 Visualization of the phenolic compounds and cultivars on the two dimensional map

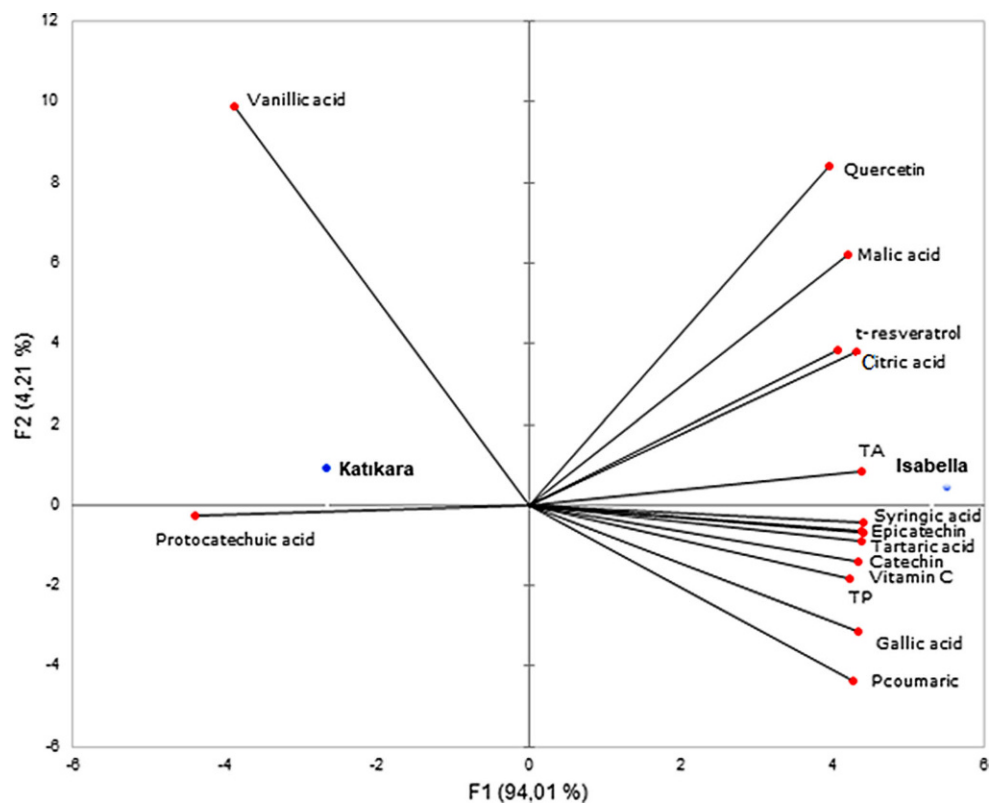
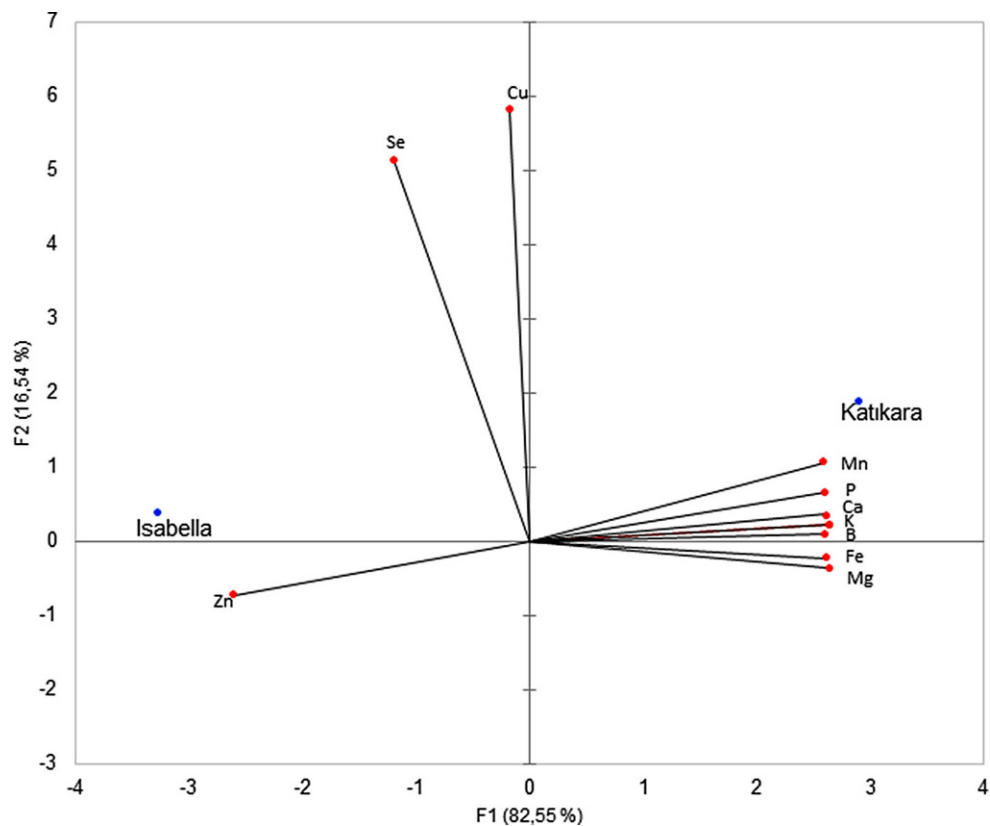


Fig. 2 Visualization of the minerals and cultivars on the two dimensional map



the human body (Ribeiro et al. 2015; Canturk et al. 2016; Keskin et al. 2019). A diet rich in potassium is very important for human health as it lowers blood pressure and therefore the risk of morbidity owing to cardiovascular diseases, and it also reduces the risk of developing osteoporosis by reducing urinary calcium excretion (Sousa et al. 2014). Calcium is also involved in the building of bones and teeth and regulation of certain body processes in the human body, while iron is associated with the production of blood cells, among other functions (Belitz et al. 2009).

Categorical Principal Component Analysis (CATPCA) was performed to determine the relationships among the mineral elements as well as to dimension reduction. Visualization of the minerals and two cultivars of the two dimensional map is presented in Fig. 2. As seen in Fig. 2; Mn, P, Ca, K and B are located in the upper-right region of the map. Only Fe and Mg are located on the lower-right region. There are highly and positively correlations among these minerals and 'Katkara' variety. Si and Cu with 'Isabella' are located on the upper-left region while only Zn on the lower-left region. Zn is highly correlated with 'Isabella'. According to the first dimension which accounts for 82.55% of the variation, 'Katkara' is strongly and negatively correlated with 'Isabella' for the considered minerals. Similarly, Zn, Si and Cu are highly and negatively correlated with the other minerals for the first dimension. Zn is also strongly and negatively correlated with Se and Cu for the second dimension which accounts for 16.54% of the variation. Thus, it can be noted that 'Katkara' is likely to be appropriate for higher Mn, P, Ca, K, B, Fe and Mg minerals. Similarly, 'Isabella' is likely to be considered for higher values of the Zn.

Conclusion

The results obtained from this study showed significant differences between the two grape varieties in relation to the biochemical compounds and antioxidant activity. In general, 'Isabella' was richer for total phenolics, organic acids, vitamin C and antioxidant activity than the 'Katkara', excluding mineral elements. Considering the antioxidant activity of the extracts obtained from two different grape varieties, it was observed that 'Isabella' has the greatest potential as a source of compounds that can be applied as a natural antioxidant in foods. Additionally, the antioxidant activity of evaluated two grape varieties was strongly correlated with the phenolic compounds. Besides, we observed that the 'Katkara' was cultivated widely in the Eastern Black Sea region of Turkey with high mineral elements. To sum up, since the phenolic content of grapes is heavily influenced by both genotype and environmental factors,

additional data on samples from different vineyards and successive vintages should be collected in future research.

Author Contribution NK, and HBE made a significant contribution to experimental design, acquisition of data, analysis and drafting of the manuscript. OK and SK has made a substantial contribution to interpretation of data, drafting and carefully revising the manuscript for intellectual content. All authors read and approved the final manuscript.

Conflict of interest N. Keskin, H. Bilir Ekbic, O. Kaya and S. Keskin declare that they have no competing interests.

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