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DETERMINATION OF TOTAL PHENOLIC AND FLAVONOID CONTENT OF BERRY SKIN, PULP AND SEED FRACTIONS OF ÖKÜZGÖZÜ AND BOĞAZKERE GRAPE CULTIVARS

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Abstract

Grape cultivars (Vitis vinifera L.*) are believed to have health benefits due to their antioxidant activityand phenolic content. Thus, scientists have conducted research to explore their positive effects on many human diseases. The aim of this study was to determinetotal phenolic and flavonoid contents of berry pulp, seed and skin of Öküzgözü and Boğazkere red wine grape cultivars grown in Turkey. In conclusion, it was found that total phenolic (µg GAE/mg) and flavonoid content in Ökügözü and Boğazkere grape cultivars showed importantdifferences according to the berry skin, pulp, seed and research years. The highest phenolic content was found in Öküzgözü berry pulp 803.00 µg GAE/mg in 2012 year. When the flavonoid amounts are compared, it has been determined that the total flavonoid amount varied from 5.08 µg QUE/mg to 111.55 µg QUE/mg. The highest flavonoid content was found in the Öküzgözü grape berry skin in 2011 year (111.55 µg QUE/mg). This study showed that these grapes are a potential source of phenolic and flavonoid compounds. It can be concluded that selected grape varieties and their parts can be considered a good source of phenolics.*

Key words*: Grape, Öküzgözü, Boğazkere, Berry, Phenolic, Flavonoid.*

INTRODUCTION

Turkey is one of the top producers of grape. It has 467,093 ha of vineyards and a production of 4.1 million tons. Over 74 million tons of grapes are grown worldwide on more than 7.1 million ha. Turkey ranks fifth in terms of growing area, after Spain, France, China, and Italy, and ranks sixth in production after China, Italy, USA, Spain and France (Anonymous, 2014).

In Turkey, grapes have been mainly grown as table grapes (52%), for raisins (38%), and for fruit juice and wine (10%), with around 80 standard cultivars grafted onto mainly six standard rootstocks, in nine viticultural regions. Turkey has about 7% of the world's area of vineyards, and produces 6.4% of the world's grape production. In addition, productivity in Turkey has improved by about 40% in the last 15 years, from 6654 kg ha^{-1} in 1998 to 9249 kg ha^{-1} in 2012 (Soylemeoglu et al., 2016).

Turkey is the one of the gene center of grapevines, for this reason it possesses over 1200 grape varieties. Nearly all grape varieties grown in Turkey are european-type grapes (*Vitis vinifera* L.).

The types and concentration of the phenolic compounds depend on the grape variety, ripening, climatic conditions, wine making practices (the use of enzymes, maceration conditions, and fermentation temperature), and ageing (Kelebek et al., 2007).

Among the types of grapes, especially red grapes and grape juice, the major phenolic compounds found in red wine are called as flavonoids, anthocyanins and flavonols (Rice-Evans et al., 1996; Singleton, 1982; Palomino et al., 2000). It is reported that these substances that are important in terms of human health and found in grape(Morris and Cawthon, 1982; Bravdo et al., 1985; Matthews and Anderson, 1988; Iland, 1989; Nadal and Arola, 1995; De La Hera Orts et al., 2005; Pirinccioglu et al., 2012; Ozdemir et al., 2016) vary according to the varieties of the grapes (Landrault et al., 2001), climate and soil conditions of the place

where it grows (Spayd et al., 2002; Mateus et al., 2001).

Among the climate features of the vineyard areas, the place and vector issues especially the temperature, humidity and sunlight are encountered as the important factors affecting the synthesis the of phenolic compounds.

Some authors have studied the total phenolic and flavonoid contents of different grape cultivars and ecological regions in Turkey (Deryaoglu and Canbas, 2003; Aras, 2006; Orak, 2007; Babalik et al., 2009; Baydar et al., 2009; Uluocak, 2010; Kelebek, 2009; Bayir, 2011; Cangi et al., 2011; Toprak, 2011; Kaplama, 2012; Pehlivan et al., 2015).

Öküzgözü and Boğazkere are red grape cultivars of *Vitis vinifera* L. grown in eastern Turkey, especially Elazig, Malatya, and Diyarbakir provinces. It is an important red grape variety for Turkey, which produces well-balanced and characteristics wines, with fruity notes such as strawberry, cherry, and blackberry-like odours (Cabaroglu et al., 2002; Kelebek et al., 2007)

The aim of the present study was to determine the total phenolic and flavonoid content of berry skin, pulp and seed of Öküzgözü and Boğazkere grape cultivars.

MATERIALS AND METHODS

Plant Material

This research was carried out in the Dicle University Department of Horticulture and Chemistry in 2011, 2012 and 2013 years. In the research, Öküzgözü and Boğazkere (*Vitis vinifera* L.) Turkish wine grape cultivars were used as biological material (Figures 1 and 2).

Grape varieties are grown in Elazığ (Sün Village) province.

Fresh grapes from Boğazkere and Öküzgözü cultivars were manually harvested at optimum maturity in the 2011, 2012 and 2013 vintage in Elazig province and transported to the Plant Physiology Laboratory at the Department of Horticulture, University of Dicle, located in Diyarbakir, Turkey.

Determination of total phenolic and flavonoid contents

Total phenolic and flavonoid content of the grapes obtained with different part of berries (skin, pulp, seed) (Figure 1, Figure 2) from Boğazkere and Öküzgözü grape cultivars.

Total phenolic content was determined according to Le et al. (2007); gallic acid (10–180 µg/mL) was used as standard. Samples of 40 µL of extract solution (1 mg/mL) were mixed with 200 µL Folin–Ciocalteau's phenol reagent 10% in water. After 4 min of incubation, 0.4 mL of 20% Na_2CO_3 was added. The reaction tubes were further incubated for 2 h at room temperature and the absorbance was measured at 760 nm. The concentration of total phenolic compounds in the extract was determined as µg of gallic acid equivalents per mg of extract (µg GAE/mg) (Kada et al., 2016; Ozdemir et al., 2016).

Total flavonoid content was quantified according to Bahorun et al. (1996) using quercetin (2–20 µg/mL) as standard. Briefly, samples of 1 mL of extract solution (1 mg/mL) were incubated in the presence of 1 mL of $AlCl_3$ (2%) for 10 min at room temperature. The absorbance was measured at 430 nm. Total flavonoid content was expressed as µg quercetin equivalent per mg of extract (µg QUE/mg) (Kada et al., 2016; Ozdemir et al., 2016).

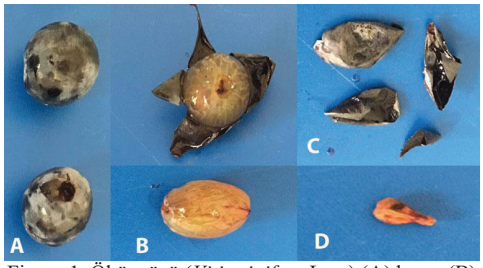

Figure 1. Öküzgözü (*Vitis vinifera* L.cv) (A) berry (B) skin, (C) pulp and (D) seed

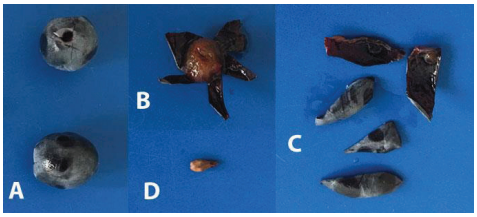

Figure 2. Boğazkere (*Vitis vinifera* L. cv) (A) berry (B) skin, (C) pulp and (D) seed

RESULTS AND DISCUSSIONS

As a result of the study, total phenolic (µg GAE/mg) content of the grape cultivars showed

differences according to the berry fractions (skin, pulp and seed) and years.
Total phenolic content varied from 85.45 µg GAE/mg to 126.70 µg GAE/mg in Öküzgözü and Boğazkere grape berry skin.
The highest values in Öküzgözü berry skin were found in 2013 year (average 89.58 µg GAE/mg).
The maximum amount of phenolic content was found in Boğazkere variety in 2012 (126.70 µg GAE/mg) (Table 1).

Table 1. Total phenolic content (µg GAE/mg) in grape berry skin

	Total phenolic content			
Cultivars	2011	2012	2013	Average
Öküzgözü	85.45	81.25	102.05	89.58
Boğazkere	100.55	126.70	107.00	111.42

Total phenolic content varied from 493.70 µg GAE/mg to 766.40 µg GAE/mg in Öküzgözü and Boğazkere grape berry pulp.
The maximum amount of phenolic content was found in Öküzgözü variety in 2013 (766.40 µg GAE/mg).
The least amount was found in the Boğazkere grape variety in 2011 (493.70 µg GAE/mg). The average values in berry skin were found in 89.58 µg GAE/mg in Öküzgözü and 523.43 µg GAE/mg in Boğazkere variety (Table 2).

Table 2. Total phenolic content (µg GAE/mg) in grape berry pulp

	Total phenolic content			
Cultivars	2011	2012	2013	Average
Öküzgözü	704.40	803.00	766.40	757.93
Boğazkere	493.70	546.60	530.00	523.43

Total phenolic content varied from 157.60 µg GAE/mg to 340.40 µg GAE/mg in grapes berry seed.
The average values in berry seed were found in 182.75 µg GAE/mg in Öküzgözü and 329.45 µg GAE/mg in Boğazkere variety.
The highest amount of phenolic content was found in Boğazkere variety in 2012 (340.40 µg GAE/mg) (Table 3).

Table 3. Total phenolic content (µg GAE/mg) in grape berry seed

	Total phenolic content			
Cultivars	2011	2012	2013	Average
Öküzgözü	157.60	183.30	207.35	182.75
Boğazkere	327.70	340.40	320.25	329.45

The total flavonoid content found in the berry skin was detected to vary from 36.16 to 111.55 µg QUE/mg. It has been detected that the flavonoid content in the skin was found in Öküzgözü grape variety in 2011 year (111.55 µg QUE/mg) and the lowest one was found in Boğazkere variety in 2013 year (36.16 mg QUE/mg). The average values in berry skin were found to be: 108.44 µg QUE/mg in Öküzgözü and 48.35 µg QUE/mg in Boğazkere variety (Table 4).

Table 4. Total flavonoid content (µg QUE/mg) in grape berry skin

	Total flavonoid content			
Cultivars	2011	2012	2013	Average
Öküzgözü	111.55	107.01	106.77	108.44
Boğazkere	54.11	54.79	36.16	48.35

Total flavonoid content varied from 17.20 µg QUE/mg to 39.66 µg QUE/mg in Öküzgözü and Boğazkere grape berry pulp. The highest flavonoid content in the pulp was found to be 39.66 µg QUE/mg in Boğazkere grape variety in 2013 year. The lowest one was found to be 17.20 µg QUE/mg in Öküzgözü variety in 2011 year. The average flavonoid values in berry pulp were found to be: 17.32 µg QUE/mg in Öküzgözü and 29.65 µg QUE/mg in Boğazkere variety (Table 5).

Table 5. Total flavonoid content (µg QUE/mg) in grape berry pulp

	Total flavonoid content			
Cultivars	2011	2012	2013	Average
Öküzgözü	17.20	17.40	17.37	17.32
Boğazkere	24.54	24.76	39.66	29.65

Total flavonoid content varied from 5.08 µg QUE/mg to 11.23 µg QUE/mg in grape berry seed.

The highest flavonoid content in the seed was found to be 11.23 µg QUE/mg in Boğazkere grape variety in 2013 year.

The lowest one was found to be 5.08 µg QUE/mg in Öküzgözü variety in 2012 year. The average flavonoid values in berry seed were found to be: 5.14 µg QUE/mg in Öküzgözü and 9.88 µg QUE/mg in Boğazkere variety (Table 6).

Table 6. Total flavonoid content (µg QUE/mg) in grape berry seed

	Total flavonoid content			
Cultivars	2011	2012	2013	Average
Öküzgözü	5.20	5.08	5.16	5.14
Boğazkere	8.08	10.34	11.23	9.88

It has been identified in different research that total phenolic amounts vary according to the variety and year and decreased during maturation period (Doshi et al., 2006; Navarro et al., 2008; Jin et al., 2009). Saidani Tounsia et al., (2009) examined the total phenolic amount in the methanol extract of three types of red grape seeds and found the equivalent of respectively 427.00 mg/100g, 218.00 mg/100g and 112.81 mg/100g of gallic acid for dry weights of Muscat, Shiraz and Carignan varieties. A similar study was carried out by Hogan et al. (2009) and it was examined the total phenolic content of the three types of Virginia black wine grapes in various regions of northern France and Cabernet in Virginia black wine grapes in northern France as Cabernet Franc 1, Cabernet Franc 2 and Cabernet Franc 3 and, as a result, they were identified to be equivalent of respectively 1.82 ± 0.07 mg/g, 1.47 ± 0.05 mg/g, 0.63 ± 0.02 mg/ g of gallic acid.

As a result of their study, Ozden and Vardin (2009) have found that the total phenolic compound concentration of some grape varieties grown in Sanliurfa conditions such as Merlot, Chardonnay, Cabernet Sauvignon and Shiraz (*V. vinifera* L.) grape varieties vary from 1805 mg/kg to 3170 mg/kg in terms of total phytochemical properties. While the highest concentration of phenolic compounds was found in Chardonnay variety, the lowest concentration was found in Shiraz variety.

In their study, Gokturk Baydar et al., (2011) have identified grape seeds and skin extracts belonging to Cabernet Sauvignon, Kalecik Karasi and Narince grape varieties, antioxidant properties of wine and the content of phenolic compounds. Total phenolic content was determined to vary from 522.49 to 546.50 mg GAE g^{-1} in seed extracts and from 22.73 to 43.75 mg GAE g^{-1} in skin extracts and from 217.06 to 1336.21 mg L^{-1} in wine. The radical scavenging effects of the samples and reducing capacities varied depending on grape varieties, the parts of the grape and the wine type.

Kanner et al. (1994) analyzed total phenolic compound amounts by harvesting the grapes in optimal harvest ripeness and the study was conducted with seven different table (Miabell Concord, Flame Seedless, Emperor, Thomson Seedless, Red Globe and Red Malaga) and seven different wine (Calzin Petite Shiraz, Merlot, Cabernet Sauvignon, Cabernet Franc, Sauvignon Blanc and Chardonnay) grapes. They reported that phenolic compounds in wine grapes vary from 230 to 1236 mg/l and Calzin and Petit Shiraz grape varieties have the highest phenolic content.

As a result of the analysis made in grape varieties examined in Elazig conditions, the total amount of phenolic and flavonoid content in the pulp, skin and seed of the berry were found to vary greatly among varieties and research years (Tables 1, 2, 3, 5 and 6).

CONCLUSIONS

It was found that total phenolic (µg GAE/mg) and flavonoid content in Öküzgözü and Boğazkere grape cultivars showed important differences according to the berry skin, pulp, seed and years.

In this research, the highest values in terms of the amount of phenolic content have been determined in the case of the pulp 803.00 µg GAE/mg in Öküzgözügrape variety.

The highest phenolic content was noticed in Öküzgözü berry seed being207.35 µg GAE/mg in 2013 year. In the skin of in Öküzgözü variety, in 2013 phenolic content was found to be 102.05 µg GAE/mg.

When the flavonoid amounts are compared, it has been determined that the total flavonoid amount varied from 5.08 µg QUE/mg to 111.55 µg QUE/mg. The highest flavonoid content was found in the Öküzgözü grape berry skin in 2011 year (111.55 µg QUE/mg).

Among plant-derived foods, fruits and vegetables are natural sources that are rich in phenolic substances. Today, it is clear that the increase in escaping from the artificial substances will increase the significance of the natural phenolic substances. Besides the use opportunities in the fields of food, ladder and pharmacology, it is seen that understanding the mechanism of action of phenolic substances with significant effects on human health and it is important to investigate the paths to be able to use technologically (Ozdemir et al., 2016).

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