

## Research Article (Araştırma Makalesi)

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**Anahtar sözcükler:** Aroma bileşenleri,  
'Bozcaada Çavuşu', sofralık üzümler

# Determinations of volatile compounds in Bozcaada Cavusu grape variety cultivated at different locations of Bozcaada

Bozcaada'nın farklı mevkilerinde yetiştirilen Bozcaada Çavuşu üzüm çeşidinde uçucu bileşenlerin oranları

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## ABSTRACT

**Objective:** The objective of this study was determine the ratios of volatile components in the 'Bozcaada Cavusu' grape variety cultivated in 'Çayır', 'Sulubahçe' ve 'Ova' locations of 'Bozcaada and conducted in 2013.

**Material and Methods:** The thirty years old goble vineyards grafted on "5BB" rootstock at different locations of Bozcaada and applied equal care conditions were selected as research material. 'Bozcaada Cavusu' grape variety was harvested at different locations at the harvest date and cluster samples were taken in the same day.

**Results:** Based on the findings from the study, it could be stated that some terpenes detected in grape varieties with 'Muscat' aroma were also major volatile components in the 'Bozcaada Cavusu' grape variety and this variety provided had a very pleasant aroma. Except terpenes, the 'Bozcaada Cavusu' grape variety was also rich in compounds with 6 carbons (C<sub>6</sub> compounds) which formed by lipoxygenase pathway, usually the desired aroma compounds in grapes and fruits.

**Conclusion:** Among these compounds, it was determined that especially E-2-hexenal and hexenal compounds were the major compounds in the aldehydes group whereas hexanol and Z-3-hexenol compounds were the major compounds in the alcohols group and they were effective in the formation of the desired flavor specific to the variety.

## ÖZ

**Amaç:** Bu araştırma, Bozcaada'nın 'Çayır', 'Sulubahçe' ve 'Ova' mevkilerinde yetiştirilen 'Bozcaada Çavuşu' üzüm çeşidinde uçucu bileşenlerin oranlarının belirlenmesi amacıyla, 2013 yılında yürütülmüştür.

**Materyal ve Yöntem:** Bozcaada'nın farklı mevkilerinde bulunan '5BB' anacı üzerine aşılı, eşit bakım şartları uygulanan 30 yaşlı goble bağlar araştırma materyali olarak seçilmiştir. 'Bozcaada Çavuşu' üzüm çeşidinin hasat tarihinde mevcut bağlarda aynı gün içerisinde salkım örnekleri alınmıştır.

**Araştırma Bulguları:** Araştırma bulgularına göre; 'Muscat' üzüm çeşitlerinde saptanmış olan bazı terpenlerin 'Bozcaada Çavuşu' üzüm çeşidinde de majör uçucu bileşen olması, yaygın olarak yetiştirilen çeşidin hoş bir aromaya sahip olmasını sağlamıştır. Genellikle üzümlerde ve meyvelerde istenilen aroma bileşiklerinden olan ve lipoksigenaz yoluyla üretilen C<sub>6</sub> bileşikler bakımından da oldukça zengin olduğu görülmektedir.

**Sonuç:** Bu bileşiklerden özellikle E-2-hekzenal ve hekzenal bileşiklerinin aldehitler grubunda, hekzenol ve Z-3-hekzenol bileşiklerinin ise alkoller grubundaki majör bileşenler olmasının, çeşide özgü istenilen aromanın oluşumunda etkili olduğu saptanmıştır.

## INTRODUCTION

Grape is one of the important species in terms of production, consumption, nutrition and health in the world and Turkey. The composition of the grape berry includes water, sugar, organic acids, phenolic compounds, pectic substances, nitrogenous compounds, enzymes, vitamins, minerals and aroma components (Kunter et al., 2013). The aroma is one of the most important quality criteria in table, raisins and wine grape varieties. Aroma components consist of compounds with different chemical properties such as hydrocarbons, esters, ketones, aldehydes and alcohols (Gomez et al., 1994; Canturk & Kunter, 2019). The major volatile compounds in grapes are terpenes, norisoprenoids, organo–sulfur compounds (thiols) and methoxyprazines (Fontes et al., 2011). The volatile compounds of grapes and wines vary between nanograms and milligrams level, the aroma components can be sensed even at very low concentrations (Selli et al., 2001). Aroma composition and concentration relate to many factor such as rootstock, climate, maturity, different cultural practices and vegetation year as well as plant species and variety (Gundogdu et al., 2018; Gur, 2019).

In terms of the vineyards in Canakkale province, Bayramic (1.963 ha), Bozcaada (1.160 ha), Gelibolu (532 ha), Eceabat (430 ha) and Ezine (204 ha) districts take the first 5 places, while these are followed by Canakkale, Lapseki, Gokceada, Biga, Ayvacik, Can and Yenice districts (Dardeniz, 2013).

Cavus grape variety is a standard table grape variety with high market value and cultivated almost everywhere in Turkey, especially in Bozcaada (Canakkale), Marmara Region (Yalova, Adapazari, Istanbul, Tekirdag, Gebze, Marmara and Islands of Avsa), Central Anatolia Region (Tokat and Konya), Inner West Black Sea Region (Karabuk and Safranbolu) and Aegean Region (İzmir and Manisa) (Tangolar et al., 1996; Anonymous, 1997; Uslu & Samanci, 1997; Kiraci et al., 2002; Dardeniz, 2002). This variety has been recommended for the Marmara, Black Sea and Central Anatolia Region for vineyards (Fidan, 1985). However, since it is most intensely cultivated in Bozcaada, it is known as the 'Bozcaada Cavusu' grape variety (Dardeniz, 2013; Eren & Dardeniz, 2015). Additionally, it was geographically registered as 'Bozcaada Cavus Grape' as of June in 2020.

Although Bozcaada Cavusu grape variety which is geographically registered, has been cultivated in almost all of Bozcaada for many years; Sulubahce, Ova and Cayir locations in Bozcaada lead for Cavus cultivation. Due to the geographical characteristics of Bozcaada, the soil and climate characteristics of these three locations can considerably differ. Therefore, it is possible to obtain different volatile compound rates in Bozcaada Cavusu grape variety cultivated at different locations.

Hence, a study was conducted and the objective of this study was to determine the rates of volatile compounds in Bozcaada Cavusu grape variety cultivated at different locations of Bozcaada.

## MATERIAL and METHODS

This research was carried out in 2013 in 3 different locations (Cayir, Sulubahce and Ova) which differ in terms of geographical location and climate characteristics where Bozcaada Cavusu grape variety are cultivated in the Bozcaada district of Canakkale province. The materials consisted of Bozcaada Cavusu grape variety grafted on 5BB grapevine rootstock.

Bozcaada is an island located in the northeast of the Aegean Sea, 12 nautical miles south of the Dardanelles. It is under the influence of the Mediterranean climate, although it doesn't have all its features due to its location. Summers are cool and droughty; winters are mild and few rainy. It is windy in all months of the year, especially during the winter months it is extremely windy. Since it is located at the exit of the Dardanelles, although it receives the north winds a lot, as well as it takes the south winds. The most important factor of vegetation is vineyard areas. The average altitude of Bozcaada is 39 meters and the meteorology station is established at an altitude of 28 meters, latitude 39°50' and longitude 26°04'. According to the detailed data of the station between 1984–2014; Bozcaada's annual average temperatures

is 15.6°C, annual amount of rainfall is 488.6 mm and average wind speed is 6 m sec<sup>-1</sup> (21.6 km h<sup>-1</sup>). The lowest humidity average is 22% in July and the highest average humidity is 39% in December and January. The average number of days with snow is 3 days a year (Anonymous, 2015). The buds on vineyards were awake between 28 March 2013 and 3 April 2013 and clusters were harvested on 31 July 2013. Based on these dates, the heat summation requirement (HSR) was calculated as 1207 degrees per days. The meteorological data of Bozcaada Island for 2013 are tabulated in Table 1.

**Table 1.** Climatic conditions of Bozcaada Island for 2013

**Çizelge 1.** Bozcaada'nın 2013 yılı iklim verileri

Months	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Relative Humidity (%)	Average Wind Speed (m/sn)	Average Temperature (°C)	Total Rainfall (mm=kg/m2)
January	16.9	-1.8	74.0	6.3	9.1	122.2
February	19.9	3.2	76.4	6.0	10.1	91.2
March	21.8	2.5	71.5	2.7	12.1	51.6
April	25.4	7.3	70.2	4.9	14.8	63.4
May	32.8	13.5	68.6	4.6	19.7	4.4
June	31.4	15.6	70.2	5.1	22.0	15.6
July	30.5	18.1	66.8	7.0	23.0	1.8
August	30.3	19.7	67.0	6.9	23.8	0.2
September	30.0	15.3	64.3	3.8	21.5	19.2
October	25.6	7.5	73.3	5.2	15.4	83.2
November	21.7	5.9	76.3	5.5	14.4	92.2
December	16.4	0.6	72.7	6.2	8.2	2.4

In the research, mixed soil samples were taken from 0–30 and 30–60 cm depths with soil sampling auger, representing study plots from vineyards in 3 different locations in autumn. Physical [saturation (%), pH, salinity (mmhos cm<sup>-1</sup>), total lime (%), organic matter (%)] and chemical [phosphorus (kg da<sup>-1</sup>) and potassium (kg da<sup>-1</sup>)] analyzes of the samples taken were made in the 'Canakkale Directorate of Provincial Agriculture and Forestry' 'Soil-Plant-Water Analysis Laboratory' (Table 2, 3 and 4).

The 30 years old vineyards of Bozcaada Cavusu grape variety that is medium high trunked goblet training system, grafted on 5BB grapevine rootstocks that belongs to a producer named Diogen Izvinko in Bozcaada. In the research, Bozcaada Cavusu grape variety vineyards at 3 different locations (Cayir, Sulubahce and Ova) are pollinated by Kuntra (Karasakiz) grape variety in the ratio of 2 to 4. The research was established in the randomized plot design with 3 replications and 4 vines were included in each repetition. In the research carried out under droughty conditions, cultural practices such as fertilization, winter pruning, tillage, disease and pest control and summer pruning of the parcels in the vineyards at 3 different locations were carried out as a standard procedure by the same producer. Fertilization was made at a fertilizer rate of 20 tons ha<sup>-1</sup> of cow manure in quadrennial each vineyard.

**Table 2.** The results from soil analysis obtained from Cayir location

**Çizelge 2.** Çayır mevkii toprak analizi bulguları

Analyses	Sample depth (cm)				
	0–30	30–60	0–30	30–60	
Physical analyses	Saturation (%)	34.0	34.0	Loamy	Loamy
	Salinity (EC) (mmhos cm <sup>-1</sup> )	0.94	0.74	Saltless	Saltless
	pH	4.71	4.65	Medium acid	Medium acid
	Total lime (%)	0.40	0.40	Less calcareous	Less calcareous
	Organic matter (%)	1.48	1.72	Low	Low
Chemical analyses	Available phosphorus (kg da <sup>-1</sup> )	18.63	19.12	Too much	Too much
	Available potassium (kg da <sup>-1</sup> )	39.44	35.53	Sufficient	Sufficient

**Table 3.** The results from soil analysis obtained from Sulubahce location**Çizelge 3.** *Sulubahçe mevkii toprak analizi bulguları*

	Analyses	Sample depth (cm)			
		0–30	30–60	0–30	30–60
Physical analyses	Saturation (%)	62.0	62.0	Clayey–loamy	Clayey–loamy
	Salinity (EC) (mmhos cm <sup>-1</sup> )	1.14	1.01	Saltless	Saltless
	pH	7.43	7.46	Neutral	Neutral
	Total lime (%)	36.46	36.46	Very calcareous	Very calcareous
	Organic matter (%)	3.09	2.49	Good	Medium
Chemical analyses	Available phosphorus (kg da <sup>-1</sup> )	8.15	6.16	Sufficient	Sufficient
	Available potassium (kg da <sup>-1</sup> )	78.39	85.67	Sufficient	Sufficient

**Table 4.** The results from soil analysis obtained from Ova location**Çizelge 4.** *Ova mevkii toprak analizi bulguları*

	Analyses	Sample depth (cm)			
		0–30	30–60	0–30	30–60
Physical analyses	Saturation (%)	44.0	44.0	Loamy	Loamy
	Salinity (EC) (mmhos cm <sup>-1</sup> )	0.98	0.78	Saltless	Saltless
	pH	7.16	7.26	Neutral	Neutral
	Total lime (%)	1.61	1.61	Calcareous	Calcareous
	Organic matter (%)	1.77	1.73	Low	Low
Chemical analyses	Available phosphorus (kg da <sup>-1</sup> )	10.06	9.23	Much	Much
	Available potassium (kg da <sup>-1</sup> )	81.99	81.99	Sufficient	Sufficient

The effect of different fertigation and irrigation treatments on fruit characteristics, vine performance and water relations of "Niagara" and "Concord" grapes that used in the fruit juice industry had been the subject of a 5-year study (Reynolds et al., 2005). Irrigation and fertigation caused a larger berry size, enhanced berry set, an increase in vine size and small increases in yield. However, all total soluble solids (TSS) were higher than minimum levels that accepted by local processors. In terms of flavor compounds especially total ester compounds and acidity and pH values of grape juices, there were no significant difference among the treatments. It was reported that the timing of fertigation treatments had no significant effect on these characteristics.

Some of the quality characteristics of the Bozcaada Cavusu grape variety obtained in the same vegetation period from the vineyards in the same locations were determined are summarized below (Eren & Dardeniz, 2015). According to this, although there is no significant difference between the locations in terms of the TSS (%), pH values and acidity (%); harvesting of vineyards in all locations were determined by the TSS% values of the grapes. The harvest was carried out when the TSS% value reached 17.5% and pH value was 3.58 in all locations on 31 July 2013. The highest maturity index was determined in Sulubahce (36.91) and the lowest maturity index in Ova (29.01) location, the intermediate group in Cayir (35.04) location. As the current crop load on the vinestock increases in grape varieties, the grape maturity is delayed (Dardeniz & Kismali, 2002). Although, pruning was made over 2 or 3 buds per annual canes in all vineyards, during winter; cluster thinning treatments were not carried out in summer pruning.

Two cluster samples taken from each vinestock were placed in PVC bags and brought to 'The Pomology Laboratory of the Faculty of Agriculture of COMU'. Volatile compounds were identified in grape samples.

Sample preparation, extraction procedure and chromatography conditions, which were carried out in order to identify the volatile components of the clusters taken from Bozcaada grape variety, were performed according to the method as proposed by Gundogdu et al (2018).

The extraction stage is as follows; 50 g of samples obtained with homogenizer were weighed and treated with 100 ml of diethyl ether solvent in an erlenmeyer flask and the solvent was concentrated into 1 ml by a centrifuge and concentrator.

The amount of the aroma volatile determined with a gas chromatograph–mass spectrometer (Shimadzu QP2010 GC/MS) fitted with a DB–WAX column (30 m x 0.25 mm ID, 0.25µm film thickness; J&W, USA). Identification of volatile content was carried out by mass spectrometry using a mass spectrometer set at 280°C of capillary direct interface temperature; the ionization energy of the mass spectrometer was programmed for 70 eV. Also the ion source temperature was set at 250°C and 40-350 amu of mass interval and 666 amu s<sup>-1</sup> scan rates. WILEY and NIST libraries were used for identification of compounds. One microliter samples were injected in 1:50 split ratio (with 250°C injection temperature) by an auto injector. Firstly, the column temperature was set at 40°C for 5 min. After the column reached at 250°C by 10°C min<sup>-1</sup> and held for 10 min.

These analyses were triplicated and every replication had berries obtained from clusters of 4 vines. The datas obtained were statistically analyzed using One–way ANOVA by the software ‘SAS ver. 9’ (SAS Institute Inc., Cary, NC, USA). Tukey multiple range test was used to determine the significance of differences between treatments means by (p<0.05). Biplot graphs were generated using the Minitab statistical program and the the correlation values between compounds were found.

## RESULTS and DISCUSSION

The results obtained from this study conducted in order to determine the ratios of volatile compounds in Bozcaada Cavusu grape variety grown at different locations of Bozcaada are presented in Table 5.

As a result of the analysis of the volatile compounds that are determined in the Bozcaada Cavusu grape variety clusters taken from different locations, a total of 42 volatile components were identified (Table 5.). These compounds were classified into groups of aldehydes (12 compounds), alcohols (12 compounds), esters (7 compounds), terpenes (7 compounds), hydrocarbons (2 compounds) and ketones (2 compounds). It was reported the 74, 35, 54, 44 and 40 number of volatile compounds in the Emir, Narince, Bornova Misketi, Kalecik Karasi and Ercis grape musts, respectively (Cabaroglu,1995; Selli, 2004; Baytin & Keskin, 2018). Jiang & Song (2010) explained that the aroma of grapes consists of volatile alcohols, aldehydes, esters, terpenes and carbonyl compounds.

Aldehydes are formed as a result of dehydrogenation of alcohols at high temperatures. Aromatic aldehydes which are abundant in nature, have some specific character (Gundogdu et al., 2021). Aldehydes constitute the major group in Bozcaada Cavusu grape variety and a total of 12 aldehydes were detected. E–2–hexenal, hexanal, E–2–octenal, nonanal, benzaldehyde, octanal, E–2–nonenal, Z–2–decenal, 2,4–hexadienal, E–5–heptenal, acetaldehyde and pentanal compounds were determined. Especially, E–2–hexenal, hexanal and E–2–octenal compounds were found to have the highest ratio in all locations.

**Table 5.** The ratio of the volatile components of the Bozcaada Cavusu grape variety obtained from different locations of Bozcaada\*  
**Çizelge 5.** Bozcaada'nın farklı mevkiilerinden elde edilen Bozcaada Çavuşu üzüm çeşidinin uçucu bileşenlerinin oranları

Aroma Components	Çayır	Sulubahçe	Ova	MSD
<b>Aldehydes</b>				
E-2-Hexenal	10.19 a**	8.22 b	10.04 a	0.350
Hexanal	7.87 b	9.58 a	8.03 b	0.555
E-2-Octenal	5.58 a	4.74 b	5.95 a	0.484
Nonanal	1.72	1.39	1.66	N.S.
Benzaldehyde	1.03	0.86	0.96	N.S.
Octanal	0.99 b	0.71 b	1.53 a	0.414
E-2-Nonenal	0.71	0.48	0.65	N.S.
Z-2-Desenal	0.70 a	0.39 b	0.46 b	0.207
2,4-Hexadienal	0.25 b	0.23 b	1.58 a	0.150
E-5-Heptanal	0.24	0.17	0.23	N.S.
Acetaldehyde	0.18 a	0.13 a	0.00 b	0.065
Pentanal	0.14 ab	0.10 b	0.17 a	0.068
<b>Total Aldehydes Area (%)</b>	<b>29.60 a</b>	<b>27.00 b</b>	<b>31.26 a</b>	<b>2.151</b>
<b>Alcohols</b>				
Hexanol	3.49 a	3.11 b	3.43 a	0.316
Z-3-Hexenol	2.28 ab	2.18 b	2.44 a	0.225
1-Octen-3-ol	2.12 a	1.78 b	1.85 ab	0.302
2-Butanol	1.15	1.07	1.04	N.S.
E-3-Octen-2-ol	0.69 ab	0.80 a	0.60 b	0.185
Phenyl Etanol	0.67 a	0.28 b	0.41 b	0.202
1-Pentanol	0.65 a	0.32 c	0.48 b	0.127
2-Propanol	0.38	0.37	0.28	0.119
2-Pentanol	0.37 a	0.13 b	0.08 b	0.114
4-Heptanol	0.24 ab	0.28 a	0.20 b	0.078
1-Hexadecanol	0.23 a	0.29 a	0.00 b	0.062
4-Octanol	0.21 a	0.19 a	0.00 b	0.073
<b>Total Alcohols Area (%)</b>	<b>12.48 a</b>	<b>10.80 b</b>	<b>10.81 b</b>	<b>0.176</b>
<b>Esters</b>				
Ethyl Acetate	7.81 a	6.63 b	7.85 a	0.320
Hexyl Acetate	1.79	1.68	1.60	N.S.
Propyl Acetate	0.80	0.79	0.83	N.S.
Ethyl Butanoate	0.68	0.50	0.55	N.S.
Z-3-Hexenyl Butanoate	0.51 a	0.32 b	0.53 a	0.113
Butyl Butyrate	0.17 a	0.00 b	0.00 b	0.072
Ethyl-2-Methyl-Butirate	0.16 a	0.00 b	0.00 b	0.043
<b>Total Esters Area (%)</b>	<b>11.92 a</b>	<b>9.92 c</b>	<b>11.36 b</b>	<b>0.512</b>
<b>Hydrocarbons</b>				
Hexadecane	0.18 a	0.10 b	0.00 c	0.053
Decane	0.11 a	0.00 b	0.00 b	0.094
<b>TOTAL HYDROCARBONS</b>	<b>0.29 a</b>	<b>0.10 b</b>	<b>0.00 c</b>	<b>0.079</b>
<b>Ketones</b>				
3-Ethoxy-2-Butanone	0.10 a	0.00 b	0.00 b	0.044
6-Methyl-5-Heptan-2-one	0.56	0.59	0.67	N.S.
<b>Total Ketones Area (%)</b>	<b>0.66</b>	<b>0.59</b>	<b>0.67</b>	<b>N.S.</b>
<b>Terpenes</b>				
Linalool	27.47 b	31.83 a	27.90 b	1.66
Geraniol	7.94 b	8.91 a	7.87 b	0.380
E-Linalool oxide	6.21 b	7.21 a	6.28 b	0.3266
Nerol	2.39 b	2.56 ab	2.93 a	0.3733
α-Terpineol	0.49	0.42	0.47	N.S.
α-Murolene	0.29 b	0.40 a	0.26 b	0.0926
Z-Citral (Neral)	0.26	0.26	0.19	N.S.
<b>Total Terpenes Area (%)</b>	<b>45.05 b</b>	<b>51.59 a</b>	<b>45.90 b</b>	<b>2.131</b>

\* Percentages obtained by GC/MS peak area normalization

\*\* Data are the means of 3 replicates with standard deviation. Values followed by different letters are significantly different at a probability level of  $P < 0.05$

The highest E-2-hexenal ratios were found in Cayir (10.19%) and Ova (10.04%) locations, respectively. E-2-hexenal aroma compounds provide perception of fresh green leaves odors in the grape berries (Anonymous, 2020). Hexanal compound, which was provided sensory perceptions such as the odour of newly mown grass and green leaves, was found in the highest in Sulubahce (9.58%) location and the lowest in the clusters of Bozcaada Cavusu grape variety cultivated in Cayir (7.87%) and Ova (8.03%) locations. E-2-Octenal was determined in the clusters of Bozcaada Cavusu grape varieties taken from the highest Ova (5.95%) and Cayir (5.58%) locations, respectively. E-2-Octenal causes sensory perceptions such as green leaves and cucumber in grape berries (Anonymous, 2020). Octanal and 2,4-hexadienal compounds were found higher Bozcaada Cavusu grape clusters cultivated in Ova (1.53%–1.58%, respectively) location, compared to Cayir (0.99%–0.25%) and Sulubahce (0.71%–0.23%) locations. The highest Z-2-decenal and acetaldehyde compounds were obtained from the Cayir (0.70% and 0.18%) location. Acetaldehyde was not detected in the clusters of Bozcaada Cavusu grape variety taken from Ova location. Pentanal, the last compound in the aldehyde group, was determined at the highest level in the Ova (0.17%) location while it was the lowest in Sulubahce (0.10%) location (Table 5.).

In a study conducted by Slegers et al. (2015), it was found that hexanal and E-2-hexenal from aldehyde group and hexanol and E-3-hexenol aroma compounds from aroma group were at the highest level in both the berry skin and grape must of Frontenac, Marechal Foch and Marquette grape varieties. Similar to Slegers et al (2015) study, in the clusters of Bozcaada Cavusu grape varieties taken from different locations, these aroma compounds are high in all three locations.

Rapp & Mandery (1986) stated that the amounts of ester and component numbers in grape berries are very low. In this research, it was detected that the amounts and numbers of esters are low as compared to other volatile compounds, and these results are supported by the findings of Rapp & Mandery (1986). It was determined that among the ester compounds, ethyl acetate was in the highest amount, and the other compounds were in very low amounts. Ethyl acetate was determined to be the highest Ova (7.85%) and Cayir (7.81%) locations, and the lowest in the Sulubahce (6.63%) location, respectively. Ethyl acetate compound adds sweet, fruity, pineapple and cherry sensory perception to grape berry (Anonymous, 2020). Z-3-hexenyl butanoate compound was detected to be the highest in Ova (0.53%) and Cayir (0.51%) locations respectively. Butyl butyrate and ethyl-2-methyl butyrate compounds were identified only in Cayir (0.17%–0.16%) location. These compounds were not detected in locations of Bozcaada.

In a study by Kalua & Boss (2010), the variation of aroma components in grape in different stages of berry development in Cabernet Sauvignon grape variety was investigated. As the berries developed and became mature, a decrease was observed in the Z-3-hexenyl butanoate compound. Also it was determined that this aroma compound disappeared in the over-mature stages. In this research, this compound was formed in lower amounts as compared to other compounds in the ester group. The fact that the Z-3-hexenyl butanoate compound was lower in the Sulubahce location, which had the highest maturity value and these findings were similar to the ones obtained by Kalua & Boss (2010).

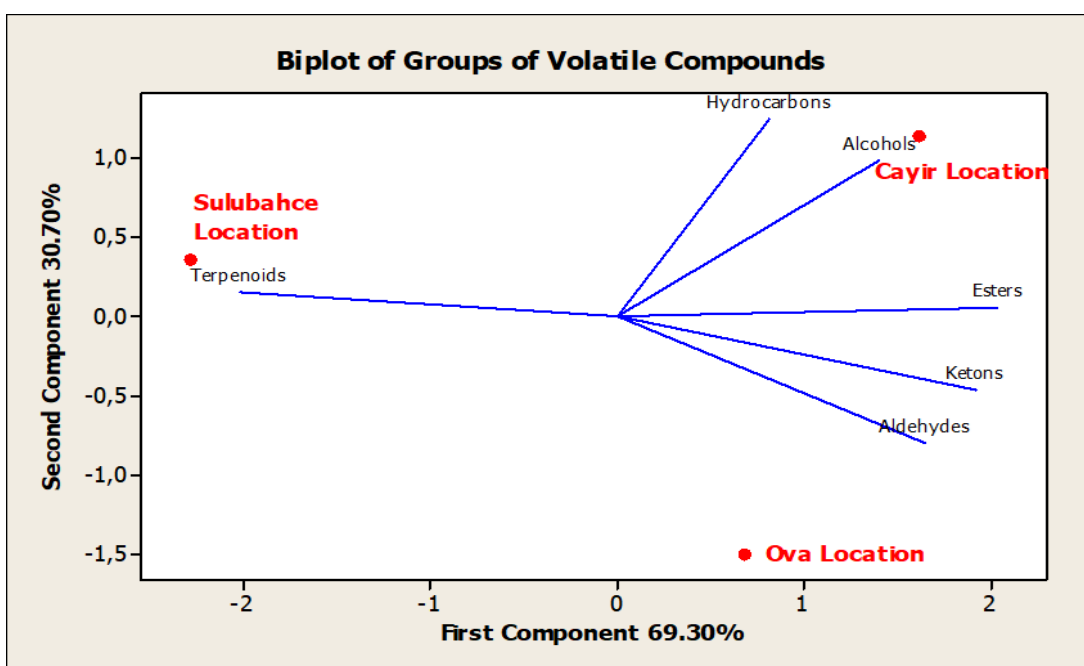
Hydrocarbons giving petrol and similar odors and ketones providing herbal, oily, citrus odors were detected in very low ratios (<1.0%) as compared to other aroma components. The presence of hexadecane and decane in hydrocarbons and 3-ethoxy-2-butanone and 6-methyl-5-heptane-2-one aroma compounds in ketones were detected.

Baytin & Keskin (2018) stated that terpenes and terpenoids are generally the main aroma components of Muscat group grape varieties. Linalool, geraniol and E-linalool oxide, the most important compounds in terpenes add citrus, flower and rose odors to grape berry (Anonymous, 2020). The highest ratios Linalool, geraniol and E-linalool oxide compounds were identified in Sulubahce (31.83%–8.91%–7.21%) location, as well as the lowest ratios in Cayir (27.47%–7.94%–6.21) and Ova (27.90%–7.87%–6.28%) locations. The highest ratio of nerol compound was obtained from cluster of Ova (2.93%) location,

in addition to the lowest ratio was detected in Cayir (2.39%) location. The highest  $\alpha$ -Murolen compound was determined in Sulubahce (0.40%) location, the the lowest in Ova (0.26%) and Cayir (0.29%) locations, respectively. Bozcaada Cavusu grape variety cultivated in the ecology of Bozcaada Island is an aromatic grape variety, with the presence of linalool and nerol compounds that are unique to this variety.

Terpene compounds were the major volatile group in Bozcaada Cavusu grape variety where cultivated in the island of Bozcaada. The highest ratios of total terpene compounds were found in Sulubahce (51.59%) location, the lowest in clusters of Bozcaada Cavusu grape variety grown in Cayir (45.05%) and Ova (45.90%) locations, respectively. The highest total aldehydes were determined in Ova (31.26%) and Cayir (29.60%) locations, the lowest in Sulubahce (27.00%) locations from the Bozcaada Cavusu grape variety. The highest ratios of total alcohols compounds were identified in Cayir (12.48%) location, the lowest ratios in Sulubahce (10.80%) and Ova (10.81%) locations, respectively. The highest ratios of total ester compounds were found in Cayir (11.92%) location, as well as the lowest in Sulubahce (9.92%) location. Total hydrocarbons were detected at very low rates. Among the different locations, the highest total hydrocarbons obtained from clusters of Bozcaada Cavusu grape variety in Cayir (0.29%) locations, the lowest in Ova (0.00%) locations. It was determined that hydrocarbons and alcohols groups were higher in Cayir location, whereas terpenes were higher in Sulubahce location (Figure 1). It was also found that the ratio of aldehyde compounds was higher in the Ova location. As seen from Figure 1, the total terpenes were inversely correlated with the total ester compounds.

Biplot charts were used in order to better understand the aroma component groups and the identify the volatile compounds (with more than 1.0%) according to the different locations in the Bozcaada Cavusu grape variety cultivated in Island of Bozcaada (Figure 1. and Figure 2.).



**Figure 1.** Biplot chart of the volatile compound groups according to the different locations in the Bozcaada Cavusu grape variety cultivated in Island of Bozcaada.

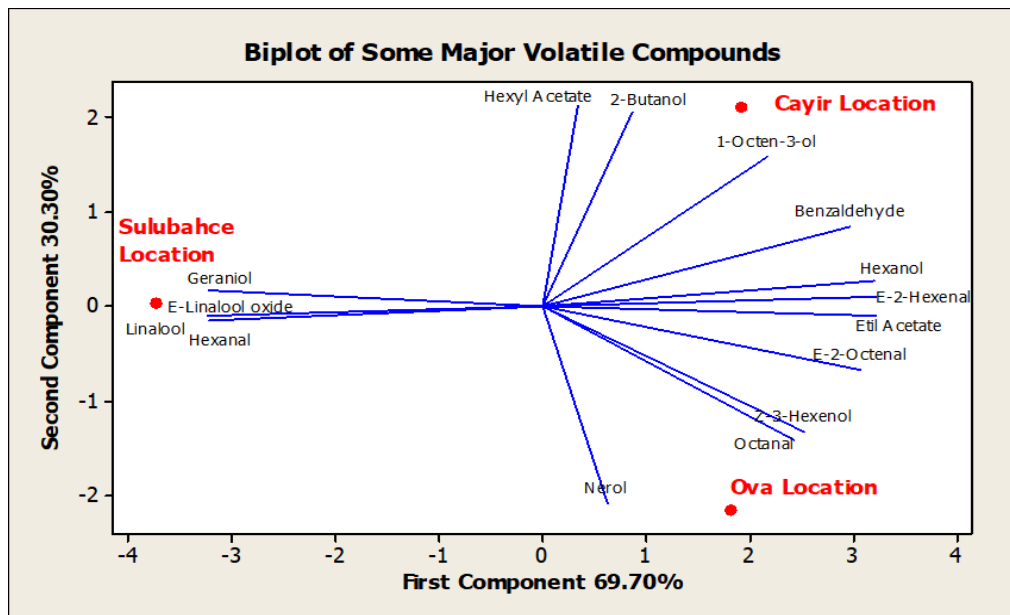
**Şekil 1.** Bozcaada'da yetiştirilen Bozcaada Çavuşu üzüm çeşidinde farklı mevkilere göre uçucu bileşik gruplarının biplot şeması

Cayir location contained more 1-octen-3-ol (2.12%) and 2-butanol (1.15%) compounds, hexyl acetate (1.78%) compound and benzaldehyde (1.03%) compound than other locations. Octanal (1.53%) aldehyde compound, Z-3-hexenol (2.44%) alcohol compound and nerol (2.93%) terpenoid compound



were detected more in the Ova location. In addition, when the interactions between compounds are examined; it can be understood that linalool (31.83%), geraniol (8.91%) and E-linalool oxide (7.21%) terpenoids and hexanal (9.58%) aldehyde compound are found in a group in Sulubahce location compared to other locations. On the other hand, it was observed that the ratios of E-2-hexenal, hexanol and ethyl acetate compounds were inversely correlated with other compound group and the ratios in Ova and Cayir locations are close to each other.

Bozcaada Island is optimum region for viticulture, and is characterized by its terroir. 'Terroir' is a French word that describes the interaction of the climate, soil and topographic effects on the vine, combined with the human factor and viticultural management practices that influence the quality of the grapes (Yigini & Ekinici, 2018).



**Figure 2.** Biplot chart of the identified volatile compounds (with more than 1%) according to the different locations in the Bozcaada Cavusu grape variety cultivated in Island of Bozcaada.

**Şekil 2.** Bozcaada'da yetiştirilen Bozcaada Çavuşu üzüm çeşidinde farklı mevkiilere göre belirlenen uçucu bileşiklerin (%1'den fazla) biplot şeması

The unique soil and climatic conditions of the region where a vine grows determine the characteristics of the grape varieties. In order to grow high quality grapes, Suitable soil and climate conditions are required along with the optimum cultivation practices. All of these are expressed with the concept of "Terroir" (Bayram et al., 2016).

As a result of the research carried out on Calkarasi grape variety cultivated in different ecological conditions in Denizli province, it was reported that the identified volatile compounds were similar, but only the differences between them were in terms of quantity (Darici, 2011).

## CONCLUSION

Especially the aroma and taste of Bozcaada Cavusu grape variety which is grown in Bozcaada, is known by many researchers and consumers today. The fact that some terpenes detected in Muscat grape varieties in the literature were also major volatile compounds in Bozcaada Cavusu grape variety,

had provided the widely grown this variety to have a pleasant aroma. Except terpenes, Bozcaada Cavusu grape variety was also rich in 6 carbon (C<sub>6</sub>) compounds, which were generally desired aroma compounds in grapes and fruit, and were produced by lipoxygenase. These compounds were E-2-hexenal, hexanal, hexanol, Z-3-hexenol and hexyl acetate compounds. Among these compounds, especially E-2-hexenal and hexanal compounds were major compounds in the aldehydes and hexanol and Z-3-hexenol compounds in the alcohols were found to be effective in the formation of the desired aroma for the variety. Bozcaada Cavusu grape variety cultivated in the ecology of Bozcaada Island is an aromatic grape variety and the presence of rich desired volatile compounds are unique to this variety.

Since the presence of some minor locality differences in the Bozcaada Cavusu grape variety grown in different locations of Bozcaada, it was thought that this situation contributed to the richness of the region taste. In this research was emphasized once again the importance of the term "Terroir" in viticulture with regard to grape aroma.

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