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ORIGINAL PAPER

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EFFECTS OF KAOLIN AND DICARBOXYLIC ACID BASED STRESS INHIBITORS ON AROMA COMPOSITION OF TWO TABLE GRAPE CULTIVARS (*V. vinifera* L.)

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ABSTRACT

In this study, effects of two stress inhibitors (particle film – PF and dicarboxylic acid – DA) on aroma composition of Beauty Seedless and Tekirdag Seedless grape cultivars were investigated. Analysis of the aroma components was carried out using solid-phase microextraction technique with gas chromatography (GC) and mass spectrometry (MS). A total of 36 and 24 aroma compounds were identified in Beauty Seedless and Tekirdag Seedless, respectively. The C_6-compounds (hexanal and 2-hexenal) were determined as the most abundant compounds in both grape cultivars and they accounted for 40.1% and 72.3% of total aroma composition in Beauty Seedless and Tekirdag Seedless, respectively. Monoterpenes (geraniol, nerol and neric acid) and sesquiterpenes (α-ylangene and germacrene) had a significant contribution of 35% to the total flavor of Beauty Seedless. Benzophenone, maltol, 6-methyl-5-hepten-2-one, 2-ethyl hexanol, 2-pentyl furan, acetic acid, hexanoic acid were other compounds detected at the highest amount. In Tekirdag Seedless, benzene acetaldehyde, 2-ethyl hexanol, maltol, 4-hexen-1-ol, acetic acid and hexanoic acid were determined as proportionally important compounds. When taken into consideration the use of stress inhibitors becoming an interesting area in viticulture, the effects of treatments in the aromatic composition is limited. In the presented study, proportional levels of any aroma compounds could not be attributed to influence of the stress inhibitors. However, findings presented useful contribution for future studies. On the other hand, this study is the first report on aroma composition of Beauty Seedless and Tekirdag Seedless grape cultivars.

Key words: volatiles, particle film, heat stress, table grape

INTRODUCTION

It has been known that the chemical composition of grape berry is quite sensitive to macro and micro environmental factors [Kuhn et al. 2014]. The ecologic and climatic conditions are influential on the synthesis and accumulation of primary and secondary metabolites in berry [Teixeira et al. 2013]. Among the climatic factors, solar radiation and temperature are the basic requirements for the metabolism of grapevine and the effects of these two parameters on berry composition and metabolism have been known for many years and nowadays considered as the primary factors for high-quality table and wine grape production [Spayd et al. 2002].

Aroma composition is one of the most important quality parameters that determine the consumer acceptance in table and wine grapes. Many factors such

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as grape cultivar, climatic factors, ripeness degree, cultural practices, winemaking process and vegetation year are influential on aroma concentration and composition of grape [Duan et al. 2014]. It is known that there is a clear relationship between aroma composition of grapes and sunlight exposure. Moreover, studies conducted in this area show that different aroma compounds give different responses to sunlight [Duan et al. 2014].

In ecologies that are dominated by intense sunlight exposure and high-temperature conditions, vines are under stress. Under high-temperature conditions, *véraison* occurs premature and as a re-sult, development of primary metabolites and aroma compounds may be reduced [Teixeira et al. 2013]. In recent years, the use of foliar-applied and clay-based reflective materials has become widespread in order to reduce the high-temperature stress. The use of kaolin-based reflective materials against stress conditions is called "particle film technology". Particle films are used in many fruit and vegetable species to reduce stress as well as to regulate the fruit yield and quality [Glenn et al. 1999, Yazıcı and Kaynak 2009, Khaleghi et al. 2015]. On the other hand, dicarboxylic acids, such as malonic, oxalic, threonic and succinic acid, that naturally occur in plant species, are involved in pathways related with stress responses [Yu et al. 2012]. It is also stated that some fatty acid-derived carboxylic acids play a role in stress defense mechanism [Okazaki and Saito 2014].

In central Anatolia, excessive summer temperatures affect the vineyards mainly from early June to September. Therefore, growers are advised to take precautions to avoid heat-induced problems. Studies on the effects of environmental stress-inhibiting materials (particle films etc.) in viticulture are still limited. In few studies conducted in this area, it has been reported that particle films can contribute to improve berry composition and wine quality in arid regions [Brillante et al. 2016, Dinis et al. 2016 and Bernardo et al. 2017].

Presented study aimed at investigating the effects of stress inhibitors treatments on the aroma composition of Tekirdag Seedless and Beauty Seedless (*V. vinifera* L.) table grape cultivars grown in dry-summer conditions.

MATERIAL AND METHODS

Plant material

The study was performed during the growing season of 2016 on cv. Beauty Seedless (Queen of Vineyard × Black Kishmish) and Tekirdag Seedless (released from the national breeding program, crossing combination: Alphonse Lavallée × Sultana). Both cultivars have black skin color and are used for fresh consumption. The grapevines were cultivated in the vineyards of Research Station for Viticulture in Kalecik, Ankara (40°06′N 33°25′E, 670 m above sea level). The vineyards were planted in 2005 with 1.5 × 3 m row spacing. Grapevines were grafted on 1103P rootstock and trained bilateral cordon. In the vineyard, Beauty Seedless and Tekirdag Seedless grape cultivars are grown in different plots apart from each other. Also, a cultivar plot is divided into two blocks for application of each stress inhibitors and two untreated rows released between them. Characteristics of vineyard soil were clay-loam with a pH of 7.5. The research region has characteristics of continental climate, which is quite warm and arid, with limited precipitation. Main climatic conditions in 2016 vegetation were given in Table 1. Meteorological data were obtained from the climatic station of Turkish State Meteorological Service located in the research area.

Treatments

Two different stress inhibitors were used in present study. Kaolin-based particle film (PF) (Screenduo, CMM Inc.) and dicarboxylic acid-based stress inhibitor (DA) (Photon 500SG, CMM Inc.) were applied to the leaves just after berry set with a backpack sprayer. The PF was applied weekly for three weeks (on 16, 23 and 30 June in Beauty Seedless; on 23, 30 June and 8 July in Tekirdag Seedless) at a rate of 3% (w/v). The DA was applied bi-weekly three times (on 16, 30 June and 14 July in Beauty Seedless; on 23 June, 8 and 21 July in Tekirdag Seedless) at a rate of 4% (w/v). Untreated vines were left as controls. Grapes of Beauty Seedless were manually harvested on August 24, 2016 and Tekirdag Seedless on September 14, 2016. Grape samples were stored at –25°C until analysis.

Table 1. Climatic conditions of research vineyard (Kalecik-Ankara) in 2016 vegetation

Months	Daily mean temperature (°C)	Daily mean total sunshine (h)	Rainfall (mm)
March	8.4	5.36	51.8
April	15.1	6.28	12.8
May	15.9	8.37	52.6
June	22.6	10.27	37.6
July	24.8	11.26	3.6
August	25.9	10.53	26.2
September	19.5	9.21	16.6

Extraction of aroma compounds

Solid phase microextraction technique was used for the extraction of aroma compounds [Shalit et al. 2001]. Berry samples were homogenized in a blender and 8 g of homogenate was transferred to a vial. 2 ml of saturated NaCl solution were added on and vortexed for 30 s. The sample was equilibrated at 65°C for 30 min with 65 µm polydimethylsiloxane/divinylbenzene fiber (PDMS/DVB) (Supelco, Bellefonte, PA, USA) under stirring and then inserted into the injection port of GC for 5 min. The fiber was conditioned in GC injection port at 200°C for 20 min before analysis.

GC-MS analysis

GC-MS analysis of aroma compounds was performed using Shimadzu GCMS-QP-2010 Chromatograph equipped with a capillary column (Restek RTX-5) (30 m × 0.25 mm i.d. × 0.25 µm film thickness). Helium with 1 mL/min flow rate was used as the carrier gas. Injection temperature was 250°C and the oven temperature was set to increase from 40°C to 240°C at an increment of 4°C/min. Identification of aroma compounds was carried out by comparing their mass spectra and retention time from the WILEY and NIST library.

Statistical analysis

Data were analyzed in a completely randomized design using ANOVA. Differences among means were determined by Duncan multiple comparison test at 5% level. Statistical analyses were performed using the Statistical Package for social sciences (SPSS 20.0) software. The results were expressed in peak area (%) as a mean value.

RESULTS AND DISCUSSION

In the study, a total of 36 and 24 volatile compounds were identified in Beauty Seedless and Tekirdag Seedless, respectively (Tab. 2 and 3). The classification and percentage of aroma compounds in the cultivars is shown in Fig. 1.

The C_6-compounds were the most abundant in both grape cultivars. This group accounted for 40.1% of total aroma composition in Beauty Seedless. They accounted for more than half of total aroma composition with 72.3% in Tekirdag Seedless. Two compounds, hexanal and 2-hexenal, had the highest values in the total flavor of both cultivars. C_6 compounds are produced from linoleic and linolenic acids, which derive from plasma membrane *via* lipoxygenase activity. This reaction results in the formation of saturated and non-saturated C_6 alcohols and aldehydes. The concentrations of C_6 alcohols and aldehydes depend on a variety, ripeness degree, temperature regime and duration of contact with the skins [Moreno and Peinado 2012]. Pre-fermentative steps like harvesting, transport, crushing and pressing also contribute to the formation of these compounds [Oliveira et al. 2006]. They produce green or vegetal aroma and can generate undesirable flavor in wines. In our study, it was thought that it was effective in detecting the high content of C_6 compounds, mechanical processing between harvest and extraction. In addition, crushing and homogenization of berries during extraction might contribute to the release of high amount of C_6 aldehydes. It has also been reported by some authors that C_6 compounds are the most abundant volatiles present in grapes, which is in agreement with our study [Song et al. 2012, Wu et al. 2016].

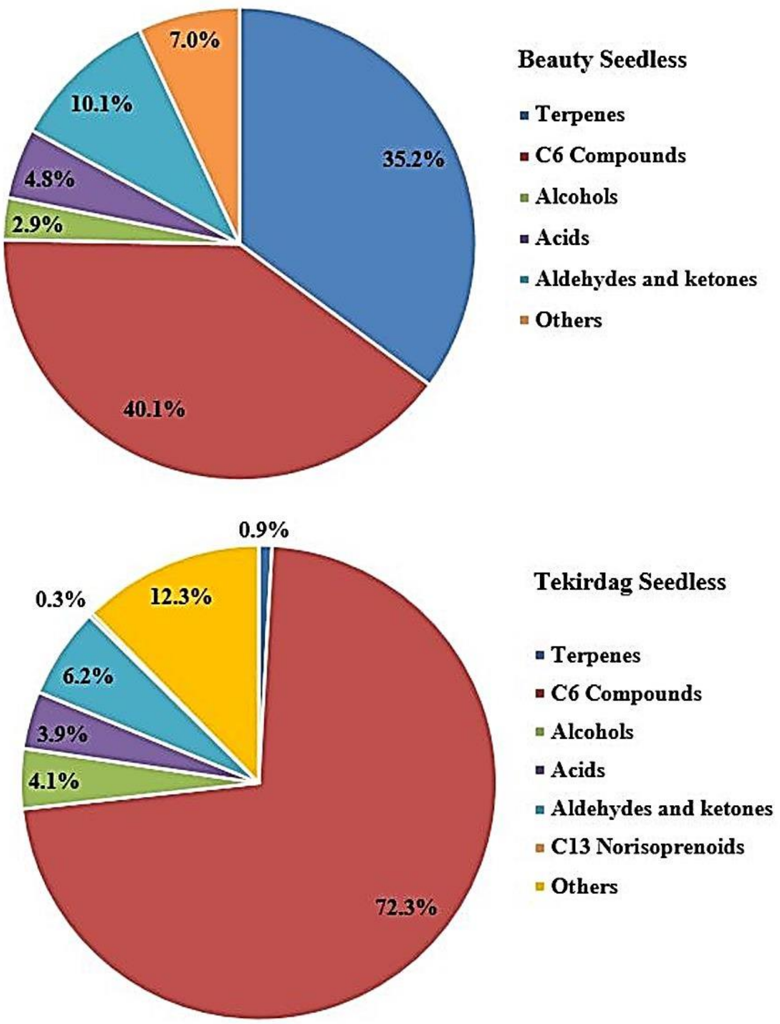

Fig. 1. Percentage of aroma compounds of Beauty Seedless and Tekirdag Seedless

Table 2. Volatile composition of Beauty Seedless

Aroma compounds	RI	RT	Peak area (%) ± SD		
			PF	DA	C
Acetic acid	703	2.574	2.35 ±0.29	2.23 ±0.10	2.43 ±0.04
Hexanoic acid	1024	14.201	1.17 ±0.06	0.97 ±0.29	1.17 ±0.07
Trans-2-hexenoic acid	1060	15.622	0.60 ±0.02a	0.48 ±0.04b	0.41 ±0.03 b
Benzoic acid	1217	22.612	0.47 ±0.03b	0.33 ±0.02b	0.69 ±0.03 a
Dodecanoic acid	1631	34.595	0.57 ±0.05	0.36 ±0.02	0.25 ±0.06
1-Octen-3-ol	1021	14.105	0.54 ±0.03	0.63 ±0.04	0.71 ±0.10
2-Ethylhexanol	1075	16.168	1.12 ±0.05	1.19 ±0.01	1.33 ±0.22
Benzene methanol	1080	16.376	0.34 ±0.04	0.43 ±0.06	0.38 ±0.01
Benzene ethanol	1164	19.537	0.41 ±0.06	0.32 ±0.02	0.29 ±0.01
2,6,6-trimethyl-2-cyclohe-xan-1-methanol	1229	21.872	0.35 ±0.01	0.36 ±0.05	0.26 ±0.01
Hexanal	816	6.497	19.56 ±0.34	22.14 ±0.53	25.13 ±1.75
2-Hexanal	878	8.633	17.95 ±0.61	19.13 ±0.56	16.44 ±1.16
Limonene	1072	16.053	0.43 ±0.02b	0.49 ±0.00ab	0.57 ±0.05a
Dihydro-myrcene	1120	17.879	0.87 ±0.12	0.79 ±0.07	0.57 ±0.04
Linalool	1149	18.985	0.53 ±0.12	0.42 ±0.03	0.23 ±0.02
Menthol	1227	21.795	0.50 ±0.08	0.40 ±0.02	nd
Geraniol	1285	23.832	6.68 ±0.46	7.68 ±0.58	7.56 ±0.27
Nerol	1312	24.773	20.26 ±0.05	22.27 ±0.57	20.03 ±1.50
Citral	1330	25.355	0.81 ±0.02a	0.66 ±0.01ab	0.51 ±0.05b
Neric acid	1415	28.122	2.63 ±0.41	2.30 ±0.07	2.02 ±0.14
α-Ylangene	1437	28.813	0.40 ±0.07b	0.40 ±0.07b	0.74 ±0.6a
Germacrene-D	1498	30.705	1.99 ±0.79	1.55 ±0.52	1.39 ±0.34
Heptanal	934	10.727	0.54 ±0.09	0.45 ±0.05	0.48 ±0.0
2-Heptanal	995	13.101	0.40 ±0.05	0.33 ±0.06	0.21 ±0.02
Benzaldehyde	999	13.127	0.28 ±0.04	0.38 ±0.04	0.31 ±0.01
Benzene acetaldehyde	1089	16.709	0.45 ±0.02	0.38 ±0.01	0.48 ±0.07
2-Octenal	1105	17.320	0.38 ±0.06	0.45 ±0.05	0.32 ±0.02
Nonanal	1154	19.163	0.69 ±0.03b	0.90 ±0.02a	0.97 ±0.05a
2-nonenal	1212	21.297	0.40 ±0.01	0.38 ±0.03	nd
Decanal	1261	23.002	0.32 ±0.03	0.34 ±0.03	0.42 ±0.04
Maltol	1124	18.053	2.47 ±0.36	2.42 ±0.20	1.62 ±0.09
Benzophenone	1705	36.668	1.15 ±0.13b	1.02 ±0.03b	2.72 ±0.16a
6-methyl-5-hepten-2-one	1030	14.430	1.03 ±0.10	1.00 ±0.05	1.06 ±0.07
2-pentyl furan	1033	14.570	1.15 ±0.13b	1.02 ±0.03 b	2.72 ±0.16a
2,2,11,11-tetramethyl-dodecane	1380	27.004	0.56 ±0.04	0.51 ±0.05	nd
Heptadecane	1462	29.604	0.41 ±0.09	0.38 ±0.10	0.49 ±0.04

Different letters within rows indicates significant differences among treatments ($p < 0.05$), nd: not detected
RI: retention index, RT: retention time (min), PF: particle film, DA: dicarboxylic acid, C: control, SD: standard deviation

Table 3. Volatile composition of Tekirdag Seedless

Aroma compounds	RI	RT	Peak area (%) ± SD		
			PF	DA	C
Acetic acid	705	2.625	1.08 ±0.02b	1.20 ±0.06 b	1.46 ±0.02 a
Butanoic acid	914	9.961	nd	nd	0.69 ±0.02
Hexanoic acid	1028	14.375	1.49 ±0.04 b	1.95 ±0.04 a	1.65 ±0.04 b
Benzoic acid	1217	21.445	0.21 ±0.02 c	0.54 ±0.04 a	0.45 ±0.02 b
Dodecanoic acid	1632	34.623	0.35 ±0.00b	0.34 ±0.01b	0.54 ±0.01a
4-Hexen-1-ol	883	8.821	3.36 ±0.12 a	2.31 ±0.01 b	2.43 ±0.05 b
1-Octen-3-ol	1022	14.123	0.32 ±0.00 b	0.29 ±0.01 b	0.38 ±0.02 a
2-Ethylhexanol	1075	16.192	1.28 ±0.03a	0.95 ±0.07 b	1.08 ±0.06 b
Hexanal	819	6.499	66.10 ±1.06a	55.72 ±1.63b	57.25 ±2.19b
2-Hexanal	878	8.653	11.72 ±0.26b	16.01 ±1.04a	10.23 ±0.69b
Limonene	1072	16.079	0.11 ±0.01	0.16 ±0.02	nd
Dihydro-myrcene	1120	17.903	0.53 ±0.03	0.49 ±0.04	0.49 ±0.04
Menthol	1227	21.805	0.29 ±0.04	0.30 ±0.01	0.38 ±0.02
β-ionone	1558	32.487	0.28 ±0.02	0.28 ±0.01	0.27 ±0.01
Heptanal	934	10.735	0.34 ±0.01	0.40 ±0.02	0.30 ±0.04
2-Heptanal	996	13.119	0.49 ±0.04b	0.61 ±0.04a	0.42 ±0.01b
Benzaldehyde	999	13.223	0.28 ±0.01b	0.33 ±0.01a	0.30 ±0.01b
2,4 Heptadienal	1040	14.845	0.44 ±0.03	0.60 ±0.05	0.45 ±0.03
Benzene acetaldehyde	1089	16.735	1.03 ±0.02	0.98 ±0.04	1.05 ±0.03
2-Octenal	1093	16.889	0.50 ±0.02	0.51 ±0.01	0.46 ±0.02
Nonanal	1155	19.187	0.57 ±0.02b	0.87 ±0.01a	0.53 ±0.04b
Decanal	1262	23.025	0.37 ±0.02a	0.26 ±0.02b	0.28 ±0.01b
Maltol	1127	18.172	1.55 ±0.03c	2.40 ±0.03a	1.93 ±0.07b
6-Methyl-5-hepten-2-one	1030	14.445	0.24 ±0.00b	0.41 ±0.03a	0.22 ±0.02b

Different letters within rows indicates significant differences among treatments ($p < 0.05$), nd: not detected
RI: retention index, RT: retention time (min), PF: particle film, DA: dicarboxylic acid, C: control, SD: standard deviation

A total of 10 terpene compounds were defined in Beauty Seedless, some of them are monoterpenes, and others are sesquiterpenes. Geraniol, nerol, linalool, limonene, citral, menthol, dihydro-myrcene, neric acid, α-ylangene and germacrene D were identified in this group. Terpene compounds had significant contribution of 35% to the total flavor of these cultivars. Terpenes are compounds that are responsible for the formation of characteristic flavor of grapes and constitute the primary aroma of wines made from Muscat varieties [Moreno and Peinado 2012]. Synthesis of terpene compounds begins at berry set and gradually rises during ripening until maturity [Günata et al. 1985]. Muscat varieties generally have more free and bound terpenes than other grape varieties, which are defined non-floral or neutral [Kalua and Boss 2010]. Among terpene compounds, nerol, geraniol and neric acid were one of the most abundant ones having characteristic floral and rose aromas of Beauty Seedless cultivars. Of these, nerol was the compound with the highest ratio constituting to 20.3–22.3% of total flavor with hexanal. α-Ylangene, which is a tricyclic sesquiterpene, has been considered as an important compound contributing to the formation of characteristic spicy and peppery aroma of Beauty Seedless. Although it is not an active aroma compound, it is responsible for the formation of spicy and peppery aroma in grapes and wines. Parker et al. [2007] have reported that α-ylangene was the best indicator for the spicy/peppery aroma in Syrah grapes, but they have could not detect it in Syrah wines. Terpene compounds were constituted about 1% of the aroma composition in Tekirdag Seedless. Limonene, menthol and dihydro-myrcene of this group were identified in very low quantities.

The other important aromatic group, in terms of proportions, was aldehydes and ketones. Fourteen compounds were identified in this group (10%) in the overall aromatic composition of Beauty Seedless. These compounds, that have citrus, floral, vegetal, fatty and sweet aromas, contribute the characteristic flavor of a given grape variety. Maltol with caramel, benzophenone with floral, powdery, 6-methyl-5-hepten-2-one and nonanal with citrus aromas were the most abundant compounds in this group. Aldehydes and ketones constitute a significant percentage (6.2%) of the total flavor of Tekirdag Seedless, in which 10 compounds were identified in this group. Among these, maltol with caramel and benzene acetaldehyde with hyacinth odor are the most abundant compounds in this group as well as in the total aroma composition.

Acids and alcohols were detected approximately in the same quantity in Beauty Seedless cultivar. Acetic acid, that is known to contribute a vinegar odor, was the dominant acid in this cultivar. Hexanoic acid came second and other acids identified were trans 2-hexenoic acid, benzoic acid and dodecanoic acid. 1-Octen-3-ol, 2-ethylhexanol, benzene methanol, benzene ethanol and 2,6,6-trimethyl-2-cyclohexen-1-methanol were identified as alcohols. Of these, 2-ethyl hexanol was one of the most abundant compounds that has a sweet floral odor. Acids and alcohols were detected in the same quantity (4%) in Tekirdag Seedless cultivar. Acetic, butanoic, hexanoic, benzoic and dodecanoic acid were identified in this group. Acetic acid and hexanoic acid had the highest quantity of acids as in Beauty Seedless. 4-Hexen-1-ol, 1-octen-3-ol and 2-ethylhexanol were determined as alcohols and 4-hexen-1-ol was one of the most abundant compounds in this cultivar.

No compounds were identified from C_{13} norisoprenoids in Beauty Seedless cultivar. In Tekirdag Seedless, β-ionone was the only compound identified from the C_{13} norisoprenoids, which contributes to the characteristic violet flavor, although its amount was very low. C_{13} norisoprenoids are aromatic compounds that originate *via* the oxidative degradation of carotenoids between *véraison* and maturity [Darriet et al. 2012]. Increased sunlight exposure leads to carotenoid breakdown, although their concentrations generally low, contribute to generating characteristic flavor of grapes and wines as they are highly odorant compounds [Razungles et al. 1998, Moreno and Peinado 2012]. Besides these, a few components, which are considered as negligible because of their very small quantities, have been identified and they accounted for about 7% of the total aromatic composition in Beauty Seedless and 12.3% in Tekirdag Seedless. Aromatic description of the compounds identified in the cultivars is presented in Table 4.

Treatments affected 8 of 36 aroma compounds identified in Beauty Seedless. There was no steady increase or decrease in these compounds, which differ proportionally from the control. While 8 of the aroma components detected in Tekirdag Seedless were not affected by the applications, there were proportional increases and decreases in the amount of 16. There was no effect of increasing or decreasing the amount of the aroma compounds of the treatments in this cultivar similar to Beauty Seedless. According to results, although two different stress inhibitors cause different effects on some aroma compounds, it was concluded that the aroma composition was not significantly affected in both cultivars. The effects of stress inhibitors on the aroma composition of different fruit species, such as particle films, have begun to be studied in recent years. Since the use of particle films in viticulture is not yet widespread, data on the effect of this technique on the aromatic composition of grape cultivars is limited. Limited number of studies in this research area has mainly focused on wine grapes and wines, so there are far fewer studies on table grapes. Kök and Bal

Table 4. Aroma description of volatile compounds in Beauty Seedless and Tekirdag Seedless

Compounds	Aroma description
Acids	
Acetic acid	strong, pungent vinegar
Hexanoic acid	unpleasant, cheesy, sweaty
Trans 2-hexenoic acid	pleasant, fatty, characteristic
Benzoic acid	almond
Butanoic acid	sweet, floral
Dodecanoic acid	fatty
Alcohols	
1-octen-3-ol	sweet, earthy, lavender, rose, hay
2-ethyl hexanol	mild sweet, floral
4-hexen-1-ol	pungent, fatty
Benzene methanol	fruity, sweet
Benzene ethanol	fresh, rose, honey
2,6,6-trimethyl- 2-cyclohexen-1-methanol	green, sweet
C_6 Compounds	
Hexanal	vegetal, grassy, green
2-hexanal	green, sweet, fruity
Terpenes	
Limonene	fresh, sweet, citrus
Dihydro-myrcene	fresh, lime, citrus
Linalool	pleasant, floral
Menthol	mint
Geraniol	characteristic rose
Nerol	fresh, sweet, rose
Citral	strong lemon
Neric Acid	sweet, floral
α-ylangene	spicy, peppery
Germacrene D	mild fruity, apple
C_{13} norisoprenoids	
β-ionone	violet, fruity, floral
Aldehydes and ketones	
Heptanal	strong, pungent, fatty
2-heptenal	pungent, green, mild fatty
2,4 heptadienal	fatty, green
Benzaldehyde	sweet, strong almond
Benzene acetaldehyde	green, floral, sweet hyacinth
2-octenal	green, leafy, mild fatty
Nonanal	citrus, rosy, fatty
2-nonenal	strong, pleasant, fatty, violet
Decanal	fatty, floral, orange
Maltol	caramel, candy, jam like
Benzophenone	mild powder, floral, rosy
6-methyl-5-hepten-2-one	fatty, green, citrus
2-pentyl furan	fruity, green bean, vegetable
2,2,11,11-tetramethyl-dodecane	odorless
Heptadecane	odorless

[2017] have reported that kaolin-based particle film + leaf removal combination increased the amount of free and bound terpene compounds in Muscat of Hamburg. Different irrigation regimes and particle film applications in the Merlot grape variety provided a slight increase in C_6 compounds, terpenes, C_{13}-norisoprenoids and shikimic acid derivatives, but the differences were not statistically significant [Song et al. 2012]. In another study carried out on Merlot, particle film application significantly increased the fresh fruit aroma and decreased the spicy flavor in wines when low irrigation conditions were applied and increased the dried fruit aroma in high irrigation conditions [Ou et al. 2010]. Coniberti et al. [2013] reported that particle film + leaf removal combinations increased the intensity of fruity and tropical flavors in Sauvignon Blanc wines.

CONCLUSION

Although the use of stress inhibitors such as particle films to reduce the heat stress is quite common in many fruit species [Glenn et al. 1999, Yazıcı and Kaynak, 2009, Khaleghi et al. 2015], the use of these materials in viticulture is limited. There are some studies about the effects of stress inhibitors on grapevine performance determined in arid conditions. Few number of studies on aroma compounds are about wine grapes and it is obvious that there is a lack of knowledge on table grapes. The present study has made a new contribution to the limited number of sources about the aroma composition of table grape cultivars and the first findings on the aroma compounds of Beauty Seedless and Tekirdag Seedless have been obtained. On the other hand, the use of stress-inhibition techniques in viticulture has been studied in recent years and studies in this area have not yet become widespread. While the accessibility of dicarboxylic acid-containing compounds is questionable, kaolin is an easily available and economical material. Based on the fact that there is no significant difference between the two stress inhibitors in terms of the effect on aroma composition in this study, it can be concluded that kaolin is a recommended material for reducing the heat stress. However, more detailed studies are needed in order to give proper suggestions on the choice of the stress inhibitor.

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