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The research of factors affecting the amount of aromatic compounds in white muscat wine samples

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Abstract

While the amount of free aromatic compounds in the juice prepared by the White method from the White Muscat grape variety cultivated in the foothill Agsu region located at an altitude of 800 m above sea level was 2040 μg/dm^3, the amount of the same compounds was 2626 μg/dm^3 in the samples prepared by storage of pomace for 5 hours. In the samples from the Samukh (79 m) region, the amount of free aromatic compounds was much lower compared to the Agsu region. A total of 35 bound aromatic compounds including 4 alcohols, 3 six-carbon compounds, 13 terpenes, 7 volatile acids, 4 volatile phenols, and 4 norisoprenoids were detected in the juice samples made from the White Muscat grape variety grown in both regions.

A total of 60 volatile compounds were found in wine samples, including 17 alcohols, 15 ethers, 13 acids, 5 aldehydes and ketones, 1 terpene, 5 volatile phenols, 4 lactones, and 1 aldehyde compound. This is much more compared to the amounts of the same compounds in juice, and it is related to the new formation processes that occur during alcohol fermentation.

Keywords: grapes; pomace; juice; wine; muscat; aroma compounds; phenolic compounds; sugar.

Practical Application: It is of practical importance for individual and large processing enterprises engaged in the production of Muscat-type juices and wines.

1 Introduction

Aroma compounds play a fundamental role in organoleptics, although they are present in very small quantities in grapes and wine. More than a thousand aroma compounds belonging to different classes have been discovered so far in grapes and wine. The effect of grape variety, agrotechnics, cultivation technology, soil, terroir, degree of ripeness of grapes, processing method, and other factors on aroma compounds was studied (Bayram et al., 2016; Fataliyev, 2011; Jabaroglu et al., 2015; Baytin & Keskin, 2018).

The study of the samples obtained from the Syrah grape variety showed that the east-west samples had higher acidity; while the north-south group had high color intensity, anthocyanins, total phenols, ash, and pH value. Volatile compounds such as alkanes, phenols, and alkyl sulfides were also found in this group. Butyrolactone and beta-damascenone were found in the east-west group. The orientation of the variety had a significant effect on the chemical composition and aroma profile (Mota et al., 2021).

The influence of the height of the grape berries from the soil on the final quality of the wine in Merlot and Chardonnay grape varieties was studied on three levels (fruit zone - FZ1: 140-200 cm above the ground; FZ2: 80-140 cm; FZ3: 20-30 cm). The height of the berries above the soil was found to affect the amount of ethyl octanoate, isoamyl acetate, ethyl hexanoate, and ethyl butanoate in the wine obtained from both varieties; In Chardonnay, it affected the amount of β-damascenone. Wines from berries located at various heights differed in the quality of aroma (Xie et al., 2016).

Ethyl propanoate, 4-mercapto-4-methyl pentane -2-one, linalool, and isovaleric acid are aroma-active compounds in Slovak white wine made from Devin vineyards, and among them, linalool is the most important aroma-active compound in the formation of the aroma of this wine (Pectka et al., 2006).

The aromatic compounds of four grape varieties (Cabernet-Sauvignon, Merlot, Chardonnay, and Italian Riesling) belonging to the Vitis vinifera species were studied at three positions. It was found that the location of berries in the middle position increased the concentration of aroma compounds in most of the studied wines (Cheng et al., 2015).

Aromatic and phenol compounds in two different wines obtained from the Muscat grape variety cultivated in different terroirs (Izmir and Manisa) were comparatively studied for two years. As a result, 53 volatile and 14 phenol compounds were detected. Menderes terroir was distinguished by a higher amount of C6 compounds, which are terpenes and aromatic compounds of the variety (Yabaci Karaoğlan & Cabaroğlu, 2020).

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The effect of applying ultrasound before fermentative maceration on the change in the amount of aromatic compounds in Muscat wines was studied. It was found that the treatment of the aromatic composition of Alexandrian Muscat wine with ultrasound for 40-80 minutes (4 hours after the initial fermentative maceration) affects volatile components. According to the obtained results, with the application of ultrasound wave for 80 minutes, there was a more noticeable difference in the aroma of white fruit, tropical fruit, stone fruit and flower, and citrus (Aragón-García et al., 2021).

The effect of cooling whole or crushed berries on the amount of volatile compounds in Muscat wines was studied. The wine obtained from frozen whole berries of the Alexandria Muscat grape variety was found to have a higher amount of aromatic compounds than the materials obtained by both crushing and traditional methods. In all cases, terpenes, acids, and complex esters were the most affected (Pedrosa-López et al., 2022).

As mentioned, various technological methods contributed to better use of the potential of free and bound aroma substances in Muscat varieties. The berry skin is richer in free and bound aroma substances. Therefore, maceration of the juice obtained by crushing the berry together with the skin for a certain period results in the penetration of those compounds into the juice. However, in this case, one important factor should be kept in mind. Thus, great amounts of phenolic compounds should not be allowed to pass into the juice along with flavoring substances. If this happens, browning occurs in the juice as a result of the oxidation of phenolic compounds that penetrate into the juice. As it can be seen, the selection of optimal technology and technological modes for the penetration of aromatic compounds into juice and wine is quite relevant. Fundamental scientific research has been conducted in many countries in this direction. However, there have not been enough studies on the juice and wines obtained from the White Muscat grape variety cultivated in the mountainous and lowland areas of our country.

The work aimed to compare the quantity and quality of aromatic compounds and the factors influencing them in juice-wine samples obtained from the White Muscat grape variety grown at different altitudes above sea level.

2 Materials and methods

Muscat grape varieties cultivated in different regions, their pomace, juice, wine material, yeast, and processing technology are taken as the research objects.

Observations were made on the ripening of the White Muscat grape variety cultivated in the foothill Aghsu (800 meters above sea level) and plain Samukh (79 meters above sea level) regions, which are located at different heights above sea level. For this purpose, average samples were taken from the vineyards and sugar amount and titratable acidity were determined on specified dates. The maturity index was determined based on these indicators. Ripe grapes were harvested and processed. The sugariness of the juice and the amount of free and bound aromatic substances were determined.

To ensure the penetration of substances from the solid parts of the berries into the juice, especially aromatic compounds, the grapes brought to micro-winemaking conditions were kept at a temperature of 1÷5 °C for 48 hours. After the separation from the comb, the berries were divided into 10 kg parts. Those parts were used as research variants. The berries were crushed and 50-75 mg/dm^3 sulfite was added. Processing was carried out by the White method, that is, by squeezing and separating pomace immediately. After that, the obtained pomace was stored at 1÷5 °C for 2 to 10 hours, the juice was extracted, and the obtained juice samples were separated from the sediment by keeping them in the refrigerator for 24 hours. Free and bound aroma compounds were analyzed in the processed juice samples, depending on the zonality (mountainous and lowland) and preparation method (control-white method, storage of pomace). Besides, samples obtained by the White method and peel maceration were subjected to spontaneous fermentation or fermentation by pure yeast solution. Analyses of common compounds in grapes and wines (pH, water-soluble dry matter (%), titratable acidity (g/dm^3), invert sugar (g/dm^3), free and total sulfur content, dry matter (g/dm^3), alcohol amount (% by volume), volatile acids (g/dm^3)) were performed based on the methods available in enochemistry (Fataliyev, 2013).

The method improved by Riu-Aumatell et al. (2004) was modified and used for the determination of aromatic compounds. 1 g of NaCl was added to the 5 ml juice sample and mixed for 30 seconds with the Vortex type mixing tool of the IKA MS3 compressor. After keeping for 40 minutes in the fiber (65 μm PDMS/DVB (Supelco, Bellefonte, PA, USA)) at 40 °C, it was injected into a GC-MS instrument (Shimadzu GCMS-QP2010). The fiber was conditioned for 10 minutes at 200 °C before each injection. Restek RTX-5 (30 m × 0.25 mm × 0.25 μm) was used as a column, and Helium was used as a carrier phase. The column temperature was programmed to increase by 4 °C per minute to reach 240 °C, after remaining for 5 minutes at 40 °C.

3 Results and discussion

As it is known, the correct determination of the grape harvest time plays a decisive role in the formation of the aroma of Muscat grape varieties. In order to determine the ripeness of the studied grape varieties, average samples were taken from the vineyards according to the instructions, and sugar and acidity were determined in them. The maturity index was determined based on those indicators. The results of observations conducted in the Aghsu region in 2019 were as follows (Table 1).

The analyses were carried out on August 15, 21, and 28, as well as on September 3. On the first day of the analysis, the sugar content was 16.1% and titratable acidity was 7.55 g/dm^3 in the White Muscat variety, while in the Pink Muscat variety these values amounted to 15.9% and 7.5 g/dm^3, respectively. During the last analysis conducted on September 3, the maturity index was 28.50 for White Muscat and 28.23 for Pink Muscat. Since there were no significant changes in the subsequent periods, the grapes were harvested on that date. Observations carried out in the Samukh region revealed three days earlier ripeness compared to the Aghsu region.

Grape processing was carried out according to the methodology, and in the control variant, the pomace was squeezed and separated immediately, while in the experimental variants, the pomace was macerated for different periods of time. The comparative analysis of the samples obtained by storing pomace for different periods of time allowed us to conclude that the 5-hour storage provided a richer material with a muscat aroma. Therefore, in the subsequent research processes, storage of pomace for 5 hours, at 1÷5 °C was used.

The results of the analysis of the general composition and aroma substances in the juice obtained by different methods are given in Table 2.

As seen, changes in the composition of the samples were noticed during storage of pomace compared to the control variant. Compared to the control, an increase in the amount of mineral substances, phenolic compounds, and total nitrogen was observed in the experimental variants. It should be noted that this technological method has an important role in increasing the aroma potential of future wine.

In this case, the aroma substances from pomace stored at a certain time and temperature, especially from its peel part, diffuse into the juice and cause an increase in the aroma potential. If this method is not used correctly, the results can be unpleasant. If the storage time of pomace and especially the temperature increase, an excess amount of phenolic compounds can pass into the juice, which causes the juice to brown and enzymatic reactions towards oxidation. As a result, the amount of six-carbon compounds that give bad taste and smell to the environment increases.

The amount of aromatic compounds in the obtained juice samples was analyzed by variants. The analysis results regarding the amount of free aroma compounds are given in Figure 1.

As seen in Figure 1, alcohols, 6-carbon compounds, terpenes, and a large number of volatile acids were found in the samples of juice prepared without storage (control) and also with storage of pomace for 5 hours (grape raw materials cultivated in the foothills and plain areas). The samples of juice made from the White Muscat grape grown in the foothill Aghsu and plain Samukh regions differ in the amount of free aroma compounds. The amounts of free aromatic substances were higher during 5 hours of storage compared to the application of the White method. The amounts of free aromatic compounds

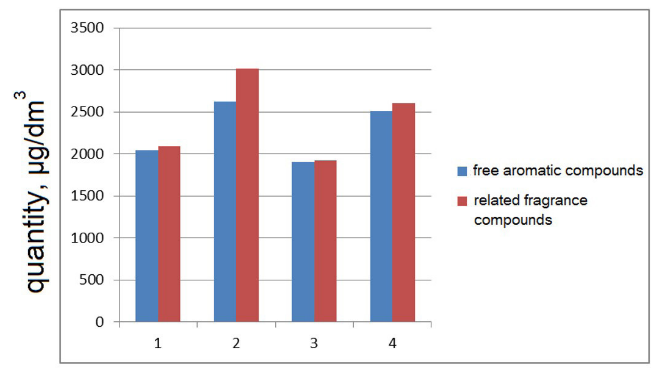

Figure 1. Changes in the amounts of free and bound aroma compounds in the juice by variants. Foothills: (1) control; (2) experiment. Lowland: (3) control; (4) experiment.

Table 1. Determination of maturity indicators in grape varieties.

Date of determination	Grape varieties					
	White Muscat			Pink Muscat		
	Sugar, %	Acid, g/dm³	Maturity index	Sugar, %	Acid, g/dm³	Maturity index
August 15, 2021	16.1	7.55	21.32	15.9	7.50	21.2
August 21, 2021	17.6	7.50	23.46	17.2	7.40	23.4
August 28, 2021	18.3	6.90	26.52	18.0	7.00	25.71
September 03, 2021	19.1	6.70	28.50	19.2	6.80	28.23

Maturity index = sugar/acidity, %.

Table 2. Physicochemical composition indicators of juice samples.

Physicochemical composition indicators	Variants			
	Foothills (Aghsu)		Lowland (Samukh)	
	Control (white method)	Storage of pomace for 5 hours	Control (white method)	Storage of pomace for 5 hours
Sugar, g/dm³	187	188	187	187
Titratable acidity, g/dm³	7.35	7.27	6.95	7.15
pH	3.45	3.50	3.51	3.55
OD280	0.06	0.08	0.07	0.09
OD420	0.101	0.145	0.135	0.160
GAI	2.54	2.57	2.60	2.61
Total nitrogen, mg/dm³	260	265	260	270
Mineral substances, g/dm³	2.45	2.60	2.55	2.75
Phenolic compounds mg/dm³	210	230	230	255

was 2040 μg/dm^3 in the juice prepared by the White method from the White Muscat variety harvested in the Agsu region, while the amount of the same compounds was 2626 μg/dm^3 in the juice prepared by storage of pomace for 5 hours.

The amount of free aromatic compounds in the samples harvested in the plain area of the Samukh region was much lower than in the Aghsu region. It should be noted that in this region there was a difference between the variants. The amount of free aromatic compounds was 1901 μg/dm^3 in the juice obtained with the White method and 2592 μg/dm^3 in the storage of pomace.

As can be seen from the qualitative analysis of the bound aromatic compounds for the mentioned variants, they are higher than the free aromatic compounds both in terms of diversity and quantity. In the foothill region, their amount was 2088 μg/dm^3 in the sample prepared by the White method, while this amount was 3001 μg/dm^3 when storage of pomace was applied. In the Samukh region, those quantities were 1927 μg/dm^3 when prepared by the White method, and 2609 μg/dm^3 in the sample obtained by storage of pomace.

A total of 35 bound aromatic compounds including 4 alcohols, 3 six-carbon compounds, 13 terpenes, 7 volatile acids, 4 volatile phenols, and 4 norisoprenoids were detected in the juice samples made from the White Muscat grape variety grown in both the foothills and the plains. It should be noted that the number of free aromatic compounds in those samples was 19, which is lower by 16. Thus, it is clear that free aromatic compounds are much less than bound aromatic compounds in terms of both diversity and quantity.

The fermentation process was carried out in pure yeast solutions and by the spontaneous fermentation method. It was found that the fermentation process significantly affected the composition of the obtained wine material. The fermentation of the juice obtained from the White Muscat grape variety was carried out both with natural yeasts and with pure yeast solutions. Depending on the processing method and the yeasts used, the physicochemical composition indicators of the obtained wines were different (Table 3).

As seen in the table, the alcohol content in spontaneous fermentation was 11.1% by volume, while in TMM fermentation it was 10.9% by volume. Titratable acidity was 6.7 g/dm^3 in spontaneous fermentation and 6.8 g/dm^3 in fermentation with TMM. The noteworthy point is that the index of phenolic compounds in the control variant was higher by 0.9 than in the experimental variant and accordingly, the browning index was higher in the experimental variant by 0.012 compared to the control variant. A decrease by 0.05 g/dm^3 was observed in the amount of volatile acids compared to the control.

The detection of aroma substances in wine samples was carried out using mass spectroscopic (MS) chromatography. The results are given below (Table 4 and Table 5).

According to Table 4 and Table 5, the wine materials obtained by the White method and maceration of pomace were prepared by spontaneous fermentation with natural yeasts and fermentation with pure yeast solutions. A total of 60 volatile compounds were found in wine samples, including 17 alcohols, 15 ethers, 13 acids, 5 aldehydes and ketones, 1 terpene, 5 volatile phenols, 4 lactones, and 1 aldehyde compound.

It appeared that the samples of wine made by the White method differ from each other due to the yeasts used. The total amount of aromatic compounds in the fermentation with pure yeasts was 185134.6 μm/dm^3 according to the two tables, while in spontaneous fermentation the amount of the same compounds increased significantly and amounted to 207484.6 μg/dm^3. A similar situation was observed in the wine samples prepared by maceration of pomace. As can be seen, maceration of pomage is noticeable with a higher amount of aromatic compounds. While the total amount of aromatic compounds in two tables during fermentation with pure yeasts in pomace maceration was 198013.219 μg/dm^3, it was 221544.7 μg/dm^3 in the samples subjected to spontaneous fermentation. It should be also noted that this quantity was higher than others.

Higher alcohols make up a very large proportion of the aromatic compounds in wine. Researchers believe that higher alcohols, the main group of aromatic compounds in Muscat wines, are formed during the fermentation process by the Ehrlich scheme or carbohydrate synthesis.

Seventeen higher alcohols were detected in wine samples obtained with different technologies and yeasts. The amount of higher alcohols was greater in spontaneous fermentation than in fermentation with pure yeasts. The comparison of samples

Table 3. Physicochemical composition indicators of wine samples.

Content indicators	Variants, depending on the method of extraction and yeast			
	White method		Storage of pomace	
	Control	TMM	Control	TMM
Alcohol, % by volume	11.1	11.0	10.9	11.0
Titratable acidity, g/dm^3	6.5	6.7	6.9	7.0
pH	3.35	3.41	3.30	3.32
Volatile acidity, g/dm^3	0.351	0.330	0.552	0. 510
Index of phenolic compounds (OD 280)	15.4	14.3	17.5	17.0
Browning (OD420)	0.121	0.098	0.165	0.131
Residual sugar (g/dm^3)	0.9	1.1	1.2	1.0
SO_2: (mg/dm^3)				
Total	75	71	58	61
Free	12	9.5	6.0	6.4

Table 4. Amount of aromatic alcohols and esters in wine samples.

Aroma compounds, µg/dm³	Variants			
	White method		Peel maceration	
	TMM	Spontaneous fermentation	TMM	Spontaneous fermentation
Alcohols				
1-propanal	142	171	135	162
Isobutyl alcohol	1115	116.4	1036	91.5
1-Butanol	26.8	20.0	23.8	18.3
4-Penten-2-ol	14.6	14.3	12.	12.0
Isoamyl alcohol	118961	134312	127660	143215
2-hexanol	21.5	18.9	25.6	21.8
2-methyl-3-pentanol	17.7	5.1	19.4	5.0
2-pentanol	4.9	4.4	5.1	4.7
1-hexanol	182	315	201	416
3-ethoxy-1-propanol	5.6	7.9	6.8	9.0
(z)-3-hexen-1-ol	165	165	177	176
3-ethyl-2-pentanol	4.1	14.5	4.9	15.2
2,3-butanediol	22.1	22.1	25.1	25.0
Methanol	58.0	55.7	62.3	59.7
Benzyl alcohol	20.8	26.4	24.1	29.7
2-phenylethyl alcohol	57865	65230	61667	69786
1H-indole-3-ethanol	203	396	212	409
Ethers				
Isoamyl butanoate	39.6	47.4	43.5	52.4
Ethyl butanoate	68.7	49.1	72.4	51.7
Isoamyl acetate	19.6	6.9	21.2	7.3
Ethyl hexanoate	131	247	135	256
Ethyl lactate	985	922	1031	965
Ethyl octanoate	195	141	204	136
Ethyl 2-hydroxyhexanoate	8.2	10.3	8.5	11.7
Ethyl decanoate	64.3	47.6	65.0	48.1
Diethyl succinate	196	242	191	264
Ethyl 4-hydroxybutanoate	93.1	67.2	85.6	70.6
Ethyl 2-hydroxy-3-phenylpropanoate	17.4	19.7	18.3	20.8
Monoethyl succinate	931	1645	987	1704
Methyl vanillate	85.7	77.4	91.3	83.2
1H-indole-3-ethanol acetate	31.2	22.1	33.0	24.1
Ethyl vanillate	12.4	16.9	13.5	17.6
Total in variants	**181704.3**	**204456.0**	**194297.4**	**218168.4**

obtained by the White method and pomace maceration showed that the amount of higher alcohols was greater in the second case.

The research revealed that the type of yeast is the most important factor in the formation of higher alcohols. Besides, the composition of the medium (sugars, pH, amino acids, and their amount), fermentation temperature, aeration conditions, and sedimentation conditions are also important factors. Isoamyl alcohol is the most abundant among higher alcohols in wines, followed by 2-phenylethyl alcohol. The amount of both alcohols in spontaneous fermentation was significantly higher than in pure yeast solution.

Ethers are important aroma substances that give the wine a fruity aroma. Especially from the aromatic point of view ethers, which give the wine fruity smells, play a fundamental role in the quality. 15 ether compounds were detected in wine samples. The total amount of ester compounds was also higher in spontaneous fermentation. Besides, pomace maceration also had a positive effect on the increase in the amount of ethers.

Among ethers, the amounts of isoamyl butanol, ethyl hexanoate, ethyl 2-hydroxyhexanoate, diethyl succinate, ethyl 2-hydroxy-3-phenylpropanoate, monoethyl succinate, and ethyl vanillate were less in wine obtained with cultured yeast compared to that prepared using spontaneous fermentation. The amount of the other eight ethers was relatively high in the control sample.

The sensory properties of Muscat wine samples were analyzed. The wine samples were evaluated by the participants according to the aroma, transparency, taste, color, and general impression. Nine tasters noted better aroma and taste of the wine samples

Table 5. Amount of acids, aldehydes, and other aromatic compounds in wine samples.

Aroma compounds, µg/dm³	Variants			
	White method		Peel maceration	
	TMM	Spontaneous fermentation	TMM	Spontaneous fermentation
Acids				
Acetic acid	106	105	109	109
Propionic acid	9.2	11.4	9.7	11.9
Isobutyric acid	19.8	41.2	20.2	43.1
Butanoic acid	49.4	54.5	51.2	57.3
Pentanoic acid	43.1	65.7	44.5	67.2
Hexanoic acid	611	512	614	521
Octanoic acid	1397	1167	1411	1207
Nonanoic acid	3.7	1.9	3.6	1.9
Decanoic acid	469	270	511	275
Dodecanoic acid	43.1	46.2	45.2	49.3
Tetradecanoic acid	38	37	39	39
Pentadecanoic acid	23.6	12.4	25.3	13.5
Hexadecanol	67.4	51.2	75.2	58.6
Aldehydes and Ketones				
Acetoin	91.2	111.3	94.2	115.6
2-Furaldehyde	2.2	5.0	2.7	6.1
Benzaldehyde	1.0	0.4	1.2	6.5
Benzeneacetaldehyde	17.1	23.2	19.0	25.1
3-hydroxy-4-phenyl-2-butanone	4.5	26.1	5.1	27.4
Terpenols				
Linalool	11.2	22.3	11.9	24.1
Phenols				
4-ethyl guaiacol	24.1	26.5	36.1	38.3
4-vinylguaiacol	36.8	33.4	46.5	52.0
Syringol (2,6-dimethoxyphenol)	6.4	8.1	5.2	9.1
Acetovanillone	11.2	26.4	22.2	21.9
Propiovanillone	21.0	22.4	22.2	21.9
Lactones				
γ-butyrolactone	165	216	252	436
Pantolactone	8.2	10.6	9.1	11.2
σ-decalactone	1.7	1.4	1.3	1.1
4-ethoxycarbonyl-γ-butanolactone	151.1	130.3	142.4	121.7
Aldehydes				
(z)-5-OH-2-methyl-1,3-dioxane	8.5	11.7	13.4	28.6
Total in variants	**3432.3**	**3028.3**	**3715.819**	**3376.3**

prepared after storage of pomace for 5 hours while color and transparency were worse compared to the control. However, in terms of general impression, the opinion of the participants coincided, the experimental sample was rated higher than the control by 0.3 points.

4 Conclusions

1. Alcohols, 6-carbon compounds, terpenes, and a large number of compounds related to volatile acids were detected in the samples of juice prepared without storage (control) and also with storage of pomace for 5 hours (from the raw materials of White Muscat grapes cultivated in the foothills and plain areas). The amount of free aromatic compounds was higher in the juice samples prepared by storage of pomace for 5 hours compared to the White method. The amount of free aromatic compounds in the juice prepared by the White method from the White Muscat variety cultivated in the Aghsu region was 2040 µg/dm³, while in the samples prepared by storage of pomace for 5 hours, the amount of the same compounds was 2626 µg/dm³;
2. The amount of free aromatic compounds in the samples harvested in the plain area of the Samukh region was much lower than in the Agsu region. It should be noted that differences were also observed between the variants in this region. Thus, the amount of free aromatic compounds in the juice obtained using the White method was 1971 µg/dm³,

while it amounted to 2532 μg/dm³ when storage of pomace was applied;

3. A total of 35 bound aromatic compounds, including 4 alcohols, 3 six-carbon compounds, 13 terpenes, 7 volatile acids, 4 volatile phenols, and 4 norisoprenoids were found in the juice samples made from the White Muscat grape variety grown in both the foothills and the plains. It should be noted that the number of free aromatic compounds in those samples was 19, which is lower by 16;

4. The alcohol content was 11.1% by volume in wine obtained with spontaneous fermentation, while it was 10.9% by volume in fermentation with TMM. Titratable acidity was 6.7 g/dm³ in spontaneous fermentation and 6.8 g/dm³ in fermentation with TMM. The noteworthy point is that the index of phenol compounds in the control variant was higher by 0.9 than in the experimental variant, and the browning index was correspondingly higher by 0.012 than in the control variant. A decrease by 0.05 g/dm³ was observed in the amount of volatile acids compared to the control;

5. A total of 60 volatile compounds were found in wine samples, including 17 alcohols, 15 ethers, 13 acids, 5 aldehydes and ketones, 1 terpene, 5 volatile phenols, 4 lactones, and 1 aldehyde compound. This is much more compared to the amounts of the same compounds in juice, and it is related to the new formation processes that occur during alcohol fermentation.

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