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Influence of Blending on the Aroma of Malvasia istriana Wine

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Summary

Malvasia istriana (*Vitis vinifera*) is a domestic and widespread grape cultivar in the Istrian wine region that gives the characteristic white wine. Istrian region is situated in the western part of Croatia (Adriatic coast). In the ageing process, Malvasia istriana loses its aroma (freshness and fruitiness) and hence it is usually consumed as a young wine. Therefore, blending is used to improve the quality of Malvasia istriana wine, to enrich its aroma and to maintain its varietal recognizability during the consumption period. Malvasia istriana base wine (85 %) was blended with Chardonnay, Sauvignon blanc, Pinot blanc, Prosecco and Muscat, from grape varieties grown in the Istrian region. The change in volatile compounds of the blends was observed throughout the year by using headspace solid phase microextraction (HS-SPME). Based on the analysis of the volatile compounds and sensory evaluation of the wine quality, the best result was obtained by blending Malvasia istriana with Sauvignon blanc and Pinot blanc. Chardonnay, Pinot blanc, Sauvignon blanc and Prosecco proved to be suitable for blending with Malvasia istriana, giving blends of high quality of the desired aroma profile. Muscat wine blended independently with Malvasia istriana or in combination with other wines proved to be unsuitable for blending due to its specific muscat aroma which dominates over the base wine aroma in the blend. Blending Malvasia istriana with other selected wines produced wines of better sensory quality, richer in volatile compounds, which can justify the blending.

Key words: blending, Malvasia istriana, volatile compounds, solid phase microextraction (SPME)

Introduction

Blending of wines of different grape varieties has a long tradition in many wine growing regions. It is a process in which two or more wines are blended in a certain ratio. The blended wine shows altered composition and organoleptic characteristics. Blending is used to achieve a desired product, the continuity of quality, to enhance complexity, improve overall quality, balance components, and bring the final product within legal or operational specifications (*1*).

The conditions for ripening of grapes in various years are not the same and hence the quality of wine is different. Deficiencies are usually expressed in unfavourable final ethanol concentration, total acidity, unappealing colour and flavour. Improvement of ethanol

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concentration and acidity are the most common reasons for blending (*2*).

Blending leads to an improvement in the sensory quality of wines, which is the result of an increased refinement and complexity of the aroma of blend wines. As common sensory characteristics of wine are frequently the result of many different compounds with varying perception thresholds, a nonlinear relationship exists between the desired target attributes of a final blend and the individual attributes of the base wines, thus complicating the blending process (*3*).

Wines are usually blended after a complete alcoholic fermentation. The ratio of the wines for blending has to be based on carefully prepared and developed blending tests in small volumes. The limits of blending are precisely defined by regulations. The regulations are restrictive in cases when the final wine has a declaration of the grape variety, vintage year and the wine-growing region. It is therefore important to note all the activities that take place during the preparation for blending and blending itself (*2*). According to the legislative regulations of the Republic of Croatia (*4*), in order for a wine to have a variety declaration, it must be produced with at least 85 % of grape variety declared on its label.

In blending, it is important to pay attention to the type and variety of the wines used. Base wines must not have pronounced differences that would cause a confusion in the final consumer. Human senses usually give non-linear responses to an increase or decrease of the bouquet. Therefore, dilution of the volatile compounds during blending does not necessarily have to decrease their perception (*2*).

Traditional methods of blending for obtaining an optimal bouquet cannot be considered adequate or reliable since successful blending depends solely on sensory evaluation. Therefore, faster and more objective methods of quality evaluation need to be developed (*2*). Recently, there has been a lot of research with the aim of improving the process of blending. Thus, Datta and Nakai (*5*) developed a computer aided method for obtaining the optimal ratio of wines for blending. They introduced a similarity coefficient for comparing blends to a series of target attributes, ranging from 0 for two totally dissimilar wines to 1 for identical wines. This approach systematically identified an optimal blend based on measurement of volatile components in base wines by headspace gas chromatography (HSGC) and comparison with a target profile. Simplex optimization was carried out to find the blend with a composition closest to the target wine (similarity coefficient close to 1).

Partial least squares regression (PLS) techniques were used to predict the colour differences in rosé wines produced by pressing of red grapes and those produced by blending red and white wines (*6*).

In his paper, Ferrier (*3*) introduces a systematic method for determining the best blend of wines given a sensory definition of the ideal wine. It combines descriptive sensory evaluation, artificial neural networks (ANNs) modelling and flexible optimization techniques to determine the blend composition that best meets the producer's goals.

Headspace solid-phase microextraction (SPME) offers a rapid, solvent-free method for extraction and determination of organic compounds from liquid samples. This method is based on the principle of adsorption of analytes onto a fused-silica fibre, which is coated with a polymer specifically selected for the target analytes. The advantages of the SPME method over other methods of extraction are numerous. SPME can be significantly faster and easier than solvent extraction methods, it is easily automated and it does not require the use of potentially toxic and expensive solvents (*7*).

The purpose of this work was to improve the sensory quality of Malvasia istriana wine, to enrich its aroma and to prolong the consumption period by blending it with quality wines while keeping the varietal recognizability at the same time.

Material and Methods

Samples

Vinification of base wine

Malvasia istriana, Chardonnay, Sauvignon blanc, Pinot blanc, Muscat and Prosecco of the vintage 2000 were used in this work. The wines were produced in the wine cellar *Minivinifikacija* of the Institute for Agriculture and Tourism in Poreč. Technical procedure of the production was performed in the following way: after pressing, the obtained must was placed into 100-litre stainless steel tanks. Then, 20 g/hL of potassium-metabisulphite was added followed by sedimentation at 12 °C for 48 h. Pure must was transferred into 70-litre stainless steel tanks. The culture of multiplied selected yeast of *Saccharomyces cerevisiae*, under the commercial name of Fermicru VB1 (Gist-brocades, France), was added in the quantity of 20 g/hL and a yeast nutrient Zimovit (Ever, Italy) in the quantity of 20 g/hL. The temperature of fermentation was kept at 17 °C. After the fermentation (sugar below 2.5 g/L), the wine was decanted to 50-litre stainless steel tanks. The stainless steel tanks were protected with inert gas (nitrogen). The wine was kept under these conditions and regularly controlled for the level of free SO_2 and corrections were made if necessary. At the end of the year, the wine was decanted again. In the period between March and May 2001, wine clarification was carried out with 100 g/hL of bentonite (Fortbenton-Ever, Italy). After that, the wine was filtered through a filter (Strassburger, Germany) followed by microfiltration (∅ 0.65 μm). Based on the physico-chemical and sensory analyses, all the base wines were categorized as quality wines.

Preparation of blending

After the filtration of wine, blending was performed. Twelve test blends were obtained by blending 6 base wines. In all the blend wines, the portion of Malvasia istriana wine was 85 %, which is the minimal amount prescribed by the Wine Regulations of the Republic of Croatia needed for a wine to have the variety declaration (*4*). Trial blends of 1-litre volume were prepared. After a three-week period, sensory evaluation of the wine was performed and, on the basis of the sensory rating, 8 blend wines listed in Table 1 were selected and

Table 1. Composition of blend wines (in volume fraction/%)

Blend wine	Base wine					
	Malvasia istriana	**Chardonnay**	**Sauvignon blanc**	**Pinot blanc**	**Muscat**	**Prosecco**
1	85	15	–	–	–	–
2	85	–	–	15	–	–
3	85	–	–	–	–	15
4	85	7.5	7.5	–	–	–
5	85	7.5	–	7.5	–	–
6	85	7.5	–	–	7.5	–
7	85	–	7.5	7.5	–	–
8	85	–	–	–	7.5	7.5

used for further research. Three weeks is considered the minimal period in which the wine is left to settle, needed for the balance between the individual components of the blended wines to be restored and for the organoleptic qualities of a new wine to be formed (*8*).

Each blending is mixed in the total volume of 20 L. Before bottling, the wine was sulphurized with SO_2, so that the portion of free SO_2 amounted to 20 mg/L. The wines were bottled into 1-litre bottles, capped with crown lids and stored at the wine cellar temperature of 15 °C. Analyses of the aroma compounds as well as sensory evaluation were performed in the period of one year.

Sensory evaluation

Sensory evaluation of the wine samples was performed using the Buxbaum model of positive rating (*9*). The model was developed on four sensory characteristics (colour, clearness, odour and taste) with the maximum of 20 points.

Sensory evaluation of the quality of the base wine, Malvasia istriana, and the 8 selected blends was performed by the panel of 6 judges, members of the Croatian Enological Society. Sensory evaluation was carried out 3 and 6 months after the blending.

Headspace-Solid Phase Microextraction (HS-SPME)

The SPME device used was a Supelco (Bellefonte, PA) manual SPME holder 57330-U. Fused silica fiber coated with polydimethylsiloxane (PDMS) 100 μm film thickness (Supelco) was used for extraction and concentration of volatile compounds. The fiber was preconditioned at 250 °C for 1 h in the inlet of the GC prior to sampling, as instructed by the manufacturer. The sample of wine (10 mL) was placed in a 20-mL vial containing internal standard *n*-amyl alcohol (180 ppm), 3-decanol (0.1 ppm), NaCl p.a. (3 g) and sealed with aluminium cover and Teflon-lined septum. HS-SPME was carried out under magnetic stirring. The SPME fiber was exposed to wine headspace at 25 °C for 15 min and immediately transferred to the GC injection port at 200 °C for 3 min in splitless mode. A 0.75 mm i.d. liner (Varian Inc.) was used.

Chromatography

A Varian 3300 gas chromatograph equipped with a flame ionisation detector (FID) was used for GC analysis. Compounds were separated on a DB 624 column (6 % cyanopropylphenyl – 94 % dimethyl polysiloxane stationary phase; 30 m × 0.32 mm, i.d. 1.8 μm; J&W Scientific, Folsom, CA). Nitrogen was used as a carrier gas at the flow rate of 5 mL/min. A split/splitless injector was used (ratio 1:5) and maintained at 200 °C. The detector was kept at 250 °C. Temperature programme was: 3 min at 40 °C, from 40 to 190 °C at 5 °C/min and 10 min at 190 °C.

The same conditions were applied for the GC-MS analysis on a Hewlett-Packard 5890 gas chromatograph with a 5970 series mass selective detector. The ionization of the samples was achieved at 70 eV under the SCAN mode. The mass range studied was from 30 to 250 m/z. Carrier gas was helium 5.0 (purity 99.999 %; Messer, Austria) at a flow rate of 5 mL/min. The constituents were identified by comparing retention times and MS spectra of the pure standard substances. The MS spectra were also compared with the data from NBS75K library spectra.

All the analyses were carried out in triplicate for each sample. The retention of wine volatiles was calculated on the basis of the peak areas of total aroma and individual components of the base wine and blending wine.

Chemicals

All the chemicals were of p.a. purity. All the standards (ethyl acetate, *i*-amyl acetate, *n*-amyl acetate, hexyl acetate, ethyl butanoate, ethyl hexanoate, ethyl octanoate, ethyl decanoate, *i*-amyl alcohol, 1-octanol, 2-phenylethanol, myrcene, linalool, nerol and benzaldehyde) were purchased from Merck, except geraniol and 3-decanol, which were obtained from Aldrich.

Similarity coefficient

Similarity coefficient was used as a mathematical model for the comparison of the chromatograph between the base wine Malvasia istriana and the blend wines throughout the year (*5*). The similarity coefficient provides the information about deviation of the blend wines in relation to the base wines. Its value ranges from 0 to 1 with 1 meaning completely identical and 0 meaning that there is no similarity. The computer programme *Mathematica, Wolfram Research, USA* was used to determine the similarity coefficient. The peak area ratio as a numerical value allows the identification of the aroma compounds of the blend wines and the base wine Malvasia istriana.

Results and Discussion

The results of sensory evaluation of wines are shown in Table 2. Sensory evaluation of wine samples was performed 3 weeks, 3 months and 6 months after blending by applying the method of positive rating according to Buxbaum's model (*9*). Odour evaluation was separated because the aroma compounds responsible for the perception of wine odour as well as overall ratings of wine samples were analysed. Keeping varietal recognizability of Malvasia istriana was one of the basic parameters that were evaluated in the samples of the blend wines. The results show that the rating of odour corresponded to the overall rating of the wine. In all three evaluated samples, Wine 7, which represents the blend of Malvasia istriana, Sauvignon blanc and Pinot blanc, has the highest mean value for odour (3.32) as well as the highest overall rating of 18.15. It is followed by Wine 1, representing the blend of Malvasia istriana and Chardonnay. Following are the sample Wine 4, which is the blend of Malvasia istriana, Chardonnay and Sauvignon blanc; and Wine 3, the blend of Malvasia istriana and Prosecco. Based on the sensory evaluation in the period of 6 months, Malvasia istriana takes the 5th position, with the overall rating of 17.78 and only the 7th position with 3.05 in the rating by odour. Muscat variety wine proved to be unsuitable for blending due to its specific aroma which dominates over the aroma of the base wine in the blend and hence the samples Wine 6 and Wine 8 have the lowest ratings. Differences between blend wines are better distinguished through sensory evaluation than by means of single components. Sensory evaluation of wines gives final and better indication of quality rather than chemical analysis (*10*).

Table 2. Results of sensory analysis of wines by *Buxbaum* method

	Malvasia istriana		Wine 1		Wine 2		Wine 3		Wine 4		Wine 5		Wine 6		Wine 7		Wine 8	
	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+	O^*	T^+
Three weeks																		
Average	3.11	17.87	3.33	17.93	3.00	17.03	3.00	17.33	3.31	17.55	3.28	17.88	3.10	17.87	3.35	18.25	2.96	17.15
Median	3.10	17.85	3.30	18.00	3.05	17.45	3.05	17.55	3.30	17.65	3.35	18.00	3.25	18.00	3.40	18.20	3.00	17.20
Three months																		
Average	3.10	17.58	3.30	17.78	3.33	17.57	3.37	18.28	3.33	18.37	3.10	17.30	2.68	16.50	3.28	18.05	2.80	17.18
Median	3.10	17.85	3.30	18.45	3.30	17.95	3.30	18.25	3.30	18.50	3.05	17.46	2.70	16.85	3.35	18.15	2.85	17.20
Six months																		
Average	2.95	17.60	3.13	17.83	3.15	17.58	3.13	17.73	3.05	17.38	2.98	17.42	2.83	17.50	3.15	18.05	2.90	16.95
Median	2.95	17.65	3.00	17.75	3.15	17.55	3.35	17.75	3.25	17.65	3.05	17.65	2.85	17.50	3.20	18.10	2.90	17.05
Total average	**3.05**	**17.68**	**3.20**	**17.84**	**3.16**	**17.52**	**3.16**	**17.78**	**3.23**	**17.77**	**3.12**	**17.53**	**2.87**	**17.29**	**3.26**	**18.12**	**2.87**	**17.09**
Total median	**3.05**	**17.78**	**3.25**	**18.07**	**3.16**	**17.65**	**3.23**	**17.85**	**3.28**	**17.93**	**3.15**	**17.70**	**2.93**	**17.45**	**3.32**	**18.15**	**2.92**	**17.15**

$^{(*)}$O – odour evaluation; maximum 4 points; $^{(+)}$T – total evaluation; maximum 20 points

The analytical data about the base wine aroma are shown in Table 3. The results obtained in this investigation are shown as the peak ratio. It was calculated by dividing the peak area of the internal standard (*n*-amyl alcohol). The actual peak area of the IS was 342 283 on average with the coefficient of variation (CV) of 3 %. The peak area ratios ranged from 0.002 to 9.647 and the CV values ranged from 2.0 to 12.1 % with the mean value of 6 %. The identified aroma compounds were divided into four groups: esters, alcohols, terpene alcohols and benzaldehyde.

The composition and ratio of esters significantly influence the sensory characteristics of wine (*11*). The fresh, fruity aroma of young wines derives in a large part from the presence of the mixture of esters. Ethyl esters of straight–chain fatty acids and acetates of higher alcohols are the dominating esters in wine, they are produced by yeast during the alcohol fermentation as a secondary product of sugar metabolism and constitute one of the largest and most important groups of compounds affecting flavour (*12*). These compounds can contribute to the evaluation of optimal wine technology but are, however, not suitable for a varietal characterisation.

The most significant acetate esters present in wine are ethyl acetate and isoamyl acetate. Concentrations of ethyl acetate contribute significantly to the volatile character of »acetic nose« and levels of 150 to 200 mg/L impart spoilage character to wine. But in very low concentrations, ethyl acetate has a pleasant odour that contributes to the olfactory complexity and has a significant influence on the quality of wine (*13*). Isoamyl acetate has an odour reminiscent of banana. Merwe and Van Wyk (*14*) showed that isoamyl acetate is the compound that contributes most to the wine aroma and also positively influences the general quality of wine. Isoamyl acetate and ethyl hexanoate play a major role in the aroma of young white wines (*15*). Similar conclusions were reached by Romano *et al.* (*16*), who showed that a simple linear model could explain the intensity of caramel/apple/acetate notes of Chardonnay wine as a function of their acetate content, mainly isoamyl acetate.

Among ethyl esters of straight-chain saturated fatty acids, the ones that were identified were ethyl butanoate, ethyl hexanoate, ethyl octanoate and ethyl decanoate. The portion of these esters in wine is far above their sensory threshold, which is ten times lower, due to the fact that these compounds are very important for the aroma of wine (*17*). Ethyl butanoate has a floral, fruity odour, ethyl hexanoate has an odour reminiscent of apples and violets, ethyl octanoate an odour reminiscent of

Table 3. Peak area ratio of identified aroma compounds in base wine

Compound*	Malvasia istriana	Chardonnay	Prosecco	Muscat	Pinot blanc	Sauvignon blanc
Acetates						
Ethyl acetate	0.216	0.171	0.184	0.188	0.174	0.204
i-Amyl acetate	0.573	0.453	0.540	0.235	0.600	0.539
n-Amyl acetate	0.029	0.046	0.041	0.030	0.034	0.055
Hexyl acetate	3.973	3.966	4.328	4.283	3.661	4.723
Ethyl esters						
Ethyl butanoate	0.045	0.056	0.074	0.094	0.093	0.067
Ethyl hexanoate	0.617	1.159	1.402	1.345	1.729	1.381
Ethyl octanoate	3.949	6.140	8.442	9.647	8.822	7.313
Ethyl decanoate	2.376	4.918	4.567	2.830	4.025	5.860
Alcohols						
i-Amyl alcohol	0.533	0.766	0.969	1.121	0.771	0.912
1-Octanol	0.237	0.442	0.053	0.398	0.194	0.526
2-Phenylethanol	0.052	0.068	0.080	0.053	0.037	0.081
Terpene alcohols						
Myrcene	0.007	0.005	0.010	0.015	0.008	0.006
Linalool	0.027	0.009	0.016	0.215	0.014	0.012
Nerol	0.016	0.020	0.010	0.153	0.009	0.024
Geraniol	0.019	0.048	0.028	0.211	0.012	0.058
Carbonyl compound						
Benzaldehyde	0.004	0.002	0.007	0.011	0.006	0.002

*Area ratio: A/IS = (peak area component)/(peak area IS); n=3; IS = internal standard *n*-amyl alcohol (180 ppm)

pineapple and pear, and ethyl decanoate has a floral odour (*2*). The most represented ester in the samples is ethyl octanoate, which corresponds to the data provided in the literature (*18*). The results show that Malvasia istriana has a significantly lower portion of ethyl esters expressed as peak area ratio, which is manifested in its decreased fruitiness and freshness and lower sensory evaluation. In young white wines the role of esters is in the creation of an aroma sensation that is reminiscent of fruits (ethyl esters) and tropical fruits (acetates of higher alcohols) (*19*).

Higher alcohols are quantitatively the largest group of aroma compounds in alcoholic beverages, and are a secondary product of alcoholic fermentation (*20*). They can be recognised by their strong, pungent smell and taste and have a significant influence on the taste and character of wine (*21*). Higher alcohols are composed of aliphatic and aromatic alcohols. Alcohols identified in the base wines are: isoamyl alcohol, 2-phenylethanol and 1-octanol. Isoamyl alcohol is the main aliphatic fusel alcohol synthesised by yeast during alcoholic fermentation. The results show that isoamyl alcohol is the most represented higher alcohol in the tested wines, which corresponds to the literature data (*22*). The most important aromatic alcohol is 2-phenylethanol. It is a higher alcohol that has the unmistakable odour of roses and is also believed to play a role in the sensory perception of the body (*23*). Viticultural conditions and the use of different yeasts contribute to considerable variations in the quantity of higher alcohols (*24*).

In the samples of base wines the following compounds were identified: myrcene, linalool, nerol and geraniol. Terpene compounds as a group form an important part of the grape bouquet. These compounds do not change during the alcoholic fermentation. The monoterpene compounds are therefore suitable for the varietal characterisation of the wine obtained from different grape varieties (*25*). The contribution of the monoterpene myrcene to the aroma of grapes has not yet been clarified (*26*). Peak area ratio of linalool, geraniol and nerol for all the base wines is almost the same apart from the wine variety Muscat, for which it is about ten times higher. For this wine, the peak area ratio is almost the same as for linalool and geraniol, which is in accordance with the research conducted by Ribéreau-Gayon *et al.* (*27*), who also confirm the same portion of linalool and geraniol in the Muscat grape variety.

The portion of linalool in Malvasia istriana wine is higher than the portion of geraniol, which is in compliance with the research of some authors (*28*). A very small number of studies on varietal compounds in the Malvasia istriana grape varieties have been published.

Benzaldehyde has an odour reminiscent of bitter almonds (*29*). Because of their low sensory threshold values, aldehydes are important for the aroma and bouquet of wine (*22*).

The analytical data on the total aroma of the base wine are shown in Table 4. The peak area ratios ranged from 21.480 to 34.066 and the CV values ranged from

Table 4. Peak area ratio of total aroma in base wine

	Malvasia istriana	Chardonnay	Prosecco	Muscat	Pinot blanc	Sauvignon blanc
Total aroma*	21.480	28.146	30.999	26.067	26.598	34.066

*Area ratio: A/IS = (peak area component)/(peak area IS); n = 3; IS = internal standard *n*-amyl alcohol (180 ppm)

2.2 to 9.8 % with the mean value of 5 %. The results indicate that Sauvignon wine, with the peak area ratio of the total aroma of 34.066, represents the base wine richest in aromatic compounds. The next wine is Prosecco with the total area of 30.999 followed by Chardonnay with the value of 28.146. Malvasia istriana has the smallest total area of 21.480, indicating that it has the least portion of aromatic compounds.

The analytical data on the aroma of the blend wines over the period of 12 months are presented in Table 5a for the samples of Wine 1 to Wine 4, whereas those for the samples of Wine 5 to Wine 8 are given in Table 5b. The actual peak area of the IS was 380 471 on average with the coefficient of variation (CV) of 4.6 %. Peak area ratios ranged from 0.001 to 7.859 and the CV values ranged from 2.1 to 12.5 %, with the mean value of 6 %. In all the samples of the blend wines, one can see a tendency of decreasing the peak area of acetate esters (ethyl acetate, isoamyl acetate and hexyl acetate). After 12 months, the aroma peak area ratio is significantly below the values of acetate esters in the base wines. The balanced portion of ethyl acetate is achieved in the period of 6 years (*25*). Perez-Coello *et al.* (*30*) established that the portion of isoamyl acetate and hexyl acetate is decreased during the storage of wine. Acetates hydrolyse to a significant degree in the early stage of wine ripening, following the kinetic behaviour described by Ramey and Ough (*31*).

During the 12-month period, the peak area ratio of the aroma for ethyl butanoate decreases in all the samples of the blend wines. The peak area ratio of the aroma for ethyl hexanoate, ethyl octanoate and ethyl decanoate shows a tendency to decrease after 12 months. Rapp and Marais (*32*) established that esters, the ratio of which in wines after the fermentation is higher than the balanced one, hydrolyse gradually until the balance with acids and alcohols is reached. Ethyl esters of the fatty acids hydrolyse more slowly than the acetate esters (*33*). It is obvious from the results that 3 weeks after blending, when the wine has stabilised and the balance among the individual aroma compounds has been established, isoamyl alcohol ratio increased significantly, compared to the values of the base wines. During storage, the portion of isoamyl alcohol decreased in all the samples of the blend wines. The peak area ratio of the aroma for 2-phenylethanol and 1-octanol increases until the 3rd month of storage, and then it decreases. After the period of 3 months, in which it increases slightly for linalool and nerol, the aroma peak area ratio for terpene compounds starts decreasing in all the samples of blends. The samples of blends Wine 6 and Wine 8, in which the base is Muscat variety, have a higher portion of terpene compounds. Chisholm *et al.* (*34*) established that the portion of monoterpenes, linalool, geraniol and nerol, decreases during wine ageing, resulting in the decrease of wine quality. The loss in terpene aroma is the result of oxidation of monoterpene alcohols into oxides that have a higher threshold of sensory sensitivity.

Blending can increase the complexity as well as the quality of wine, above all by multiplying the aroma compounds (*2*). Singleton and Ough (*35*) performed an experiment to prove that the increased aroma complexity gives wines of better quality.

Table 5a. Peak area ratio of identified aroma compounds in blends during 12 months

Compound*	Wine 1					Wine 2					Wine 3					Wine 4				
	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months
Acetates																				
Ethyl acetate	0.214	0.226	0.168	0.182	0.102	0.205	0.211	0.174	0.118	0.063	0.141	0.247	0.129	0.137	0.096	0.148	0.169	0.135	0.119	0.060
i-Amyl acetate	0.662	0.423	0.319	0.228	0.081	0.677	0.395	0.368	0.191	0.122	0.515	0.417	0.322	0.174	0.144	0.469	0.434	0.356	0.195	0.140
n-Amyl acetate	0.027	0.029	0.027	0.026	0.024	0.027	0.031	0.027	0.022	0.019	0.029	0.031	0.026	0.026	0.022	0.029	0.032	0.026	0.021	0.018
Hexyl acetate	2.470	3.332	2.457	1.972	1.792	2.048	2.733	2.048	1.876	1.705	2.394	2.448	2.178	1.617	1.191	2.914	3.294	2.048	1.365	1.165
Ethyl esters																				
Ethyl butanoate	0.092	0.070	0.069	0.053	0.049	0.096	0.061	0.029	0.011	0.011	0.104	0.071	0.053	0.024	0.013	0.085	0.070	0.066	0.031	0.022
Ethyl hexanoate	1.107	1.263	1.019	0.870	0.502	1.080	1.085	1.004	0.761	0.323	1.004	1.048	0.709	0.699	0.848	1.059	1.259	1.034	0.709	0.491
Ethyl octanoate	7.517	7.859	6.019	5.373	4.799	5.208	5.882	5.077	4.477	3.999	5.229	5.620	5.077	4.192	2.821	5.635	7.332	4.946	3.168	2.930
Ethyl decanoate	3.361	3.376	2.376	2.298	1.142	2.309	2.996	2.560	1.218	0.965	2.730	2.881	2.405	2.040	0.950	2.832	2.957	2.482	2.097	0.858
Alcohols																				
i-Amyl alcohol	1.034	0.939	0.764	0.739	0.453	1.152	0.822	0.810	0.704	0.534	0.848	0.824	0.783	0.743	0.703	1.096	0.955	0.932	0.819	0.658
1-Octanol	0.123	0.133	0.071	0.019	0.016	0.089	0.142	0.063	0.016	0.012	0.135	0.199	0.046	0.034	0.027	0.064	0.158	0.048	0.022	0.011
2-Phenylethanol	0.057	0.083	0.054	0.042	0.033	0.051	0.052	0.041	0.026	0.022	0.073	0.063	0.059	0.043	0.015	0.069	0.055	0.051	0.043	0.036
Terpene alcohols																				
Myrcene	0.013	0.009	0.003	0.002	0.001	0.007	0.004	0.002	0	0.001	0.015	0.010	0.009	0.003	0.001	0.016	0.010	0.009	0	0.002
Linalool	0.021	0.027	0.017	0.017	0.014	0.013	0.018	0.015	0.010	0.008	0.015	0.018	0.015	0.007	0.003	0.019	0.027	0.016	0.013	0.011
Nerol	0.013	0.014	0.011	0.010	0.004	0.010	0.011	0.011	0.006	0.005	0.017	0.017	0.011	0.011	0.004	0.013	0.015	0.011	0.006	0.003
Geraniol	0.008	0.005	0.004	0.004	0.001	0.016	0.011	0.009	0.004	0.001	0.022	0.011	0.006	0.004	0.003	0.013	0.008	0.005	0.004	0.002
Carbonyl compound																				
Benzaldehyde	0.005	0.003	0.003	0.001	0.001	0.010	0.009	0.006	0.003	0.002	0.011	0.006	0.003	0.002	0.001	0.012	0.007	0.004	0.002	0.002

*Area ratio: A/IS = (peak area component)/(peak area IS); n = 3; IS = internal standard *n*-amyl alcohol (180 ppm)

Table 5b. Peak area ratio of identified aroma compounds in blends during 12 months

Compound*	Wine 5					Wine 6					Wine 7					Wine 8				
	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months	3 Weeks	3 Months	6 Months	9 Months	12 Months
Acetates																				
Ethyl acetate	0.228	0.235	0.197	0.126	0.086	0.153	0.350	0.164	0.128	0.074	0.239	0.254	0.198	0.139	0.092	0.178	0.187	0.172	0.134	0.076
i-Amyl acetate	0.642	0.472	0.287	0.158	0.141	0.576	0.311	0.273	0.181	0.137	0.592	0.425	0.314	0.227	0.149	0.551	0.379	0.271	0.157	0.144
n-Amyl acetate	0.027	0.027	0.025	0.024	0.017	0.026	0.033	0.025	0.026	0.022	0.028	0.030	0.026	0.023	0.015	0.028	0.029	0.027	0.027	0.019
Hexyl acetate	1.996	3.276	1.941	1.774	1.149	1.826	2.199	2.185	2.048	1.241	3.194	3.405	2.485	1.982	1.676	3.077	3.600	2.094	1.473	0.662
Ethyl esters																				
Ethyl butanoate	0.075	0.073	0.055	0.053	0.024	0.087	0.062	0.057	0.029	0.016	0.082	0.076	0.073	0.069	0.047	0.085	0.078	0.064	0.060	0.026
Ethyl hexanoate	1.043	1.212	0.739	0.601	0.849	0.846	1.049	0.817	0.799	0.761	1.064	1.240	1.062	0.904	0.878	0.920	1.114	0.919	0.742	0.552
Ethyl octanoate	6.652	6.960	5.351	5.152	3.491	5.619	6.512	5.615	4.232	3.977	7.342	7.342	6.080	5.675	5.622	5.825	6.971	4.854	3.392	2.400
Ethyl decanoate	3.413	3.400	3.394	2.634	1.816	2.972	3.711	2.650	2.173	1.530	1.218	2.649	2.077	2.116	1.922	2.265	3.409	1.915	1.449	1.244
Alcohols																				
i-Amyl alcohol	1.067	1.007	0.707	0.738	0.736	0.895	0.783	0.738	0.724	0.694	0.988	0.955	0.814	0.766	0.761	0.922	0.852	0.755	0.743	0.748
1-Octanol	0.191	0.363	0.093	0.042	0.035	0.106	0.133	0.106	0.065	0.016	0.161	0.166	0.149	0.105	0.022	0.139	0.153	0.077	0.047	0.029
2-Phenylethanol	0.123	0.072	0.070	0.057	0.041	0.084	0.058	0.048	0.042	0.026	0.064	0.061	0.060	0.053	0.043	0.062	0.057	0.057	0.034	0.026
Terpene alcohols																				
Myrcene	0.010	0.009	0.007	0.005	0.001	0.005	0.006	0.006	0.005	0.005	0.018	0.011	0.010	0.003	0.001	0.011	0.008	0.005	0.003	0.001
Linalool	0.017	0.031	0.011	0.011	0.009	0.027	0.037	0.022	0.007	0.005	0.020	0.023	0.014	0.012	0.002	0.026	0.034	0.020	0.018	0.010
Nerol	0.014	0.021	0.014	0.009	0.004	0.013	0.027	0.013	0.006	0.002	0.014	0.015	0.013	0.011	0.006	0.020	0.032	0.014	0.010	0.004
Geraniol	0.020	0.012	0.008	0.005	0.004	0.043	0.021	0.010	0.004	0.002	0.013	0.006	0.005	0.002	0.002	0.022	0.011	0.010	0.009	0.001
Carbonyl compound																				
Benzaldehyde	0.009	0.006	0.005	0.003	0.002	0.009	0.007	0.004	0.003	0.003	0.007	0.005	0.005	0.004	0.002	0.013	0.008	0.005	0.002	0.001

*Area ratio: A/IS = (peak area component)/(peak area IS); n = 3; IS = internal standard *n*-amyl alcohol (180 ppm)

Similarity coefficients shown in Fig. 1 were calculated for the comparison of the chromatograms of Malvasia istriana base wine and the blends in the period of one year. The results indicate that the blend wines are closer to the base wine Malvasia istriana in the period up to the 3rd month, and then gradually move apart from the reference wine. Details on the peak identified are shown in Table 6. Fig. 2 shows a comparative chromatogram of Malvasia istriana base wine and the blend of Malvasia istriana, Sauvignon blanc and Pinot blanc (Wine 7), where the difference in the portion and the number of aromatic compounds are visible. The chromatogram of the blend (Wine 7) indicates an increase in the number of aroma compounds as well as an increase in the peak area of the existing compounds confirming the previously mentioned results.

Fig. 1. Similarity coefficient of the blend wines in comparison with Malvasia istriana

Table 6. Compounds identified in wine

Compound	Peak number	GC-MS confirmation[a]
Acetates		
Ethyl acetate	1	A, B
i-Amyl acetate	4	A, B
n-Amyl acetate	5	A, B
Hexyl acetate	8	A, B
Ethyl esters		
Ethyl butanoate	3	A, B
Ethyl hexanoate	7	A, B
Ethyl octanoate	12	A, B
Ethyl decanoate	15	A, B
Alcohols		
i-Amyl alcohol	2	A, B
1-Octanol	9	A, B
2-Phenylethanol	11	A, B
Terpene alcohols		
Linalool	10	A, B
Nerol	13	A, B
Geraniol	14	A, B
Carbonyl compound		
Benzaldehyde	6	A, B

[a] A, GC-MS spectra comparison with NBS75K library; B, comparison with retention time and GC-MS spectra of authentic standard

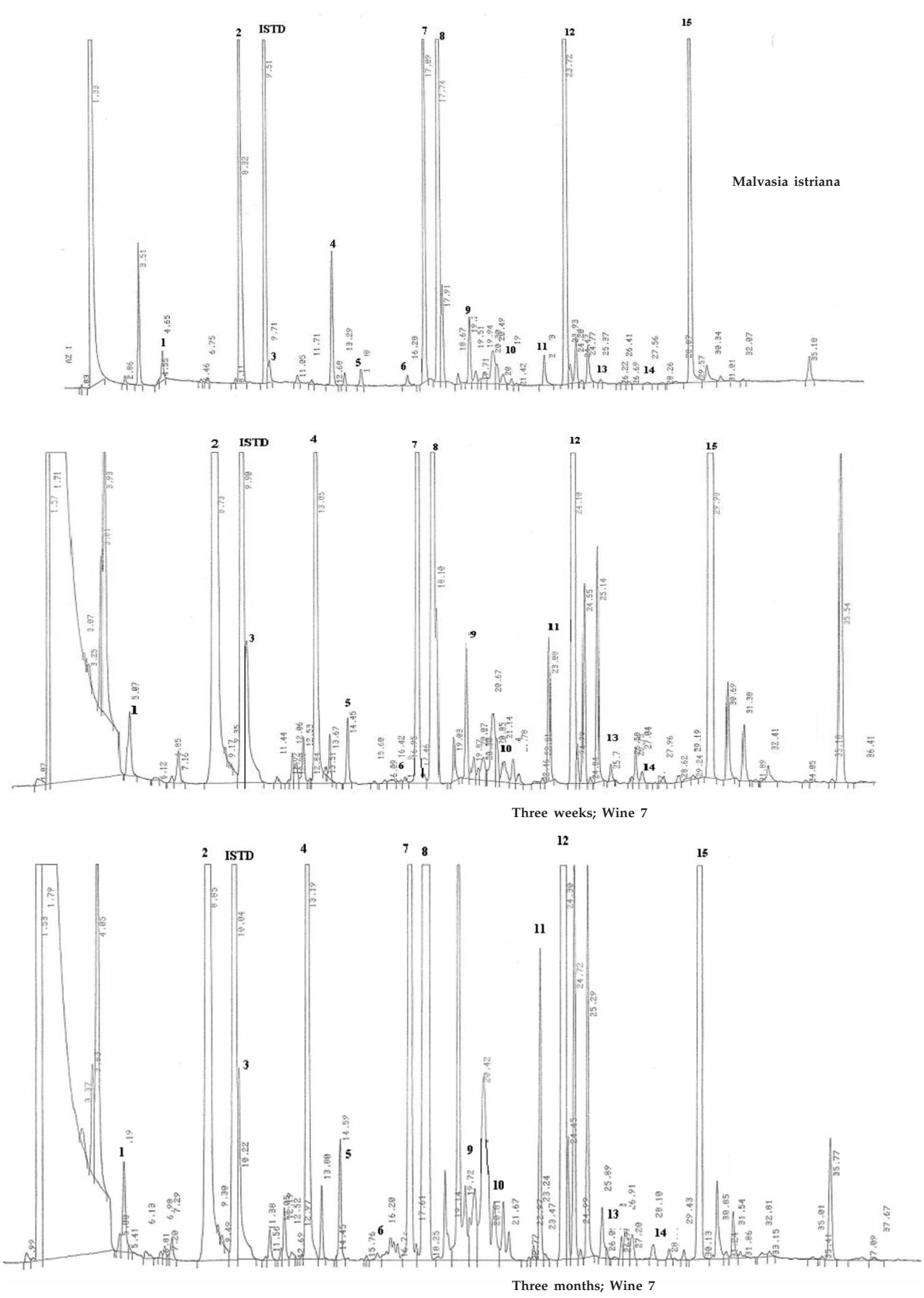

Fig. 2. Comparative chromatogram of the base wine Malvasia istriana and the blend Wine 7

Conclusions

Implementation of blending proved to be justified for the wine Malvasia istriana because its sensory quality is increased in that way, while the wine retains its varietal characteristics at the same time. On the basis of the sensory evaluation of the wine quality and the analysis of its aromatic compounds, the blend of Malvasia istriana, Sauvignon blanc and Pinot blanc was selected as the best one. Wines of the varieties Sauvignon blanc, Pinot blanc, Chardonnay and Prosecco proved to be suitable for blending with Malvasia istriana, giving quality blend wines of the desired aroma profile. Muscat independently blended with Malvasia istriana or in combination with other wines, proved to be unsuitable for blending due to its specific muscat aroma which dominates over the aroma of the base wine in the blend.

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Utjecaj kupažiranja na aromu vina Malvazija istarska

Sažetak

Malvazija istarska (*Vitis vinifera*) autohtona je i najraširenija bijela sorta grožđa u istarskoj regiji iz koje se dobiva karakteristično bijelo vino. Ta se regija nalazi u zapadnom dijelu Hrvatske, na obali Jadranskoga mora. Tijekom starenja vino Malvazija istarska gubi svoju aromu, pa se zbog toga uglavnom konzumira kao mlado vino. Kupažiranje je prove-

deno da bi se poboljšala kakvoća vina Malvazije istarske, obogatila njegova aroma i produžilo vrijeme konzumiranja te sorta ostala prepoznatljiva. Za kupažiranje je upotrijebljeno osnovno vino Malvazija istarska volumnog udjela 85 %, te Chardonnay, Sauvignon, Pinot bijeli, Prosecco i Muškat, od grožđa koje je raslo u istarskoj regiji. Tijekom jedne godine praćena je promjena hlapljivih sastojaka kupažiranih vina primjenom mikroekstrakcije na čvrstoj fazi u natprostoru (HS-SPME). Analizom hlapljivih sastojaka i senzorskom ocjenom kakvoće vina najbolji rezultati postignuti su kupažiranjem Malvazije istarske sa sortama Sauvignon i Pinot bijeli. Vina sorte Sauvignon, Pinot bijeli, Chardonnay i Prosecco bila su pogodna za kupažiranje s Malvazijom istarskom dajući vina dobre kakvoće i željene arome. Vino sorte Muškat samostalno u kupaži s Malvazijom istarskom ili u kombinaciji s drugim vinima pokazalo se nepogodnim za kupažiranje zbog svoje specifične muškatne arome koja prekriva aromu osnovnog vina u kupaži. Kupažiranjem vina Malvazija istarska s navedenim drugim vinima dobivena su vina bolje senzorske kakvoće bogatija hlapljivim sastojcima, što dokazuje opravdanost provedbe kupažiranja.