THE CONTRIBUTION OF SOME FERMENTATION PRODUCTS TO THE ODOR OF DRY WHITE WINES

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ABSTRACT

This study was undertaken in view of the general concept that some fermentation products, particularly fatty acid esters and higher alcohols affect the bouquet and quality of white table wines. Gas chromatographically purified esters and higher alcohols were added in a variety of combinations to a deodorized wine and evaluated for odor intensity and quality. A combination of six fatty acid esters at levels representative of their concentrations in premium quality white table wines, improved the odor quality and intensity significantly. A mixture of isoamyl, n-hexyl and 2-phenethyl acetate as well as a mixture of ethyl-n-hexanoate, ethyl-n-octanoate and ethyl-n-decanoate had similar quality enhancing effects, but not as pronounced as the combination of both mixtures. The addition of 100 mg/L ethyl acetate caused a highly significant decrease in odor quality, whereas additions of isoamyl alcohol and isobutyl alcohol at levels representative of their concentrations in standard white table wines, had no significant influence on the quality of the odor.

In wines of some cultivars the typical grape aroma is pronounced and easily recognizable, whereas in others the cultivar aroma is less prominent and in some cases even appears to be absent. However, most white table wines which are made from juice low in grape solids and fermented at a relatively low temperature, stabilized and bottled with the exclusion of air, have a fruity flowery bouquet which is sometimes referred to as a fermentation bouquet. It is accepted that this bouquet is to some extent related to odorous substances which are produced by the yeast during alcoholic fermentation, e.g., fatty acids and their esters, higher alcohols and carbonyl compounds. In fact, it has been shown that wines which were made under such conditions contained relatively high levels of fatty acid esters and relatively low levels of higher alcohols, whereas these ratios were reversed in wines made from high solid juice and fermented at relatively higher temperatures (14,17). Also, the former were superior in quality to the latter (17).

It was also shown that the fermentation bouquet decreases with aging (9,18). This decrease was accompanied by a decrease in the concentration of particular esters, apparently as a result of hydrolysis. These tendencies, together with the fact that significant to highly significant positive correlations between wine quality and the contents of certain esters have been found (20), strongly suggest that some esters contribute positively to wine quality. However, the addition of ethyl-n-octanoate to wine did not improve wine quality (6). On the other hand 3-methyl-1-butyl acetate (isoamyl acetate) has been shown to be a key component of the typical fermentation bouquet of young wines made from *Vitis vinifera* cultivar Pinotage (18).

This investigation concerns the addition of single, as well as combinations of esters, to a deodorized white table wine medium in order to assess their contribution to the bouquet quality of such wines. In addition, the contribution of two higher alcohols was also investigated.

MATERIALS AND METHODS

Selection of esters: A fundamental approach in this study was to first add highly purified esters to a very neutral wine medium, and then to restrict this evaluation to esters and alcohols which are formed during alcoholic fermentation of grape juice in the relative ratios in which they generally occur in premium quality white table wines. In order to conform to the latter premise, the average concentrations of a number of esters representative of 65 good quality Chenin blanc wines were determined (Table 1). In addition the average concentrations were determined for only those wines which were scored 65% and higher on general quality by a panel of 18 experienced judges. This ratio of esters was, as a result of subsequent trial odor evaluations, adapted slightly to a final level which is given in Table 1. These esters were not only evaluated in those combinations, but also in a combination of acetates only, or as a combination of the ethyl esters of the higher fatty acids. However, the same ratio or multiples of it was always used. The effects of these six esters, as well as those of ethyl acetate, isobutyl alcohol and isoamyl alcohol, were also evaluated separately.

Table 1. Concentrations of esters in Chenin blanc wines.[a]

Ester	Concentration mg/L				
	Min.	Max.	Mean	Mean best wines[b]	Selected mean
Isoamyl acetate[c]	0.68	9.52	3.78	6.0	5.0
n-Hexyl acetate	0.00	1.19	0.40	0.5	0.3
2-Phenethyl acetate	0.00	7.50	0.24	1.0	0.3
Ethyl-n-hexanoate	0.55	1.19	1.05	1.0	0.5
Ethyl-n-octanoate	0.57	2.38	1.49	1.0	1.0
Ethyl-n-decanoate	0.15	0.71	0.43	0.5	0.4

[a] 65 wines.
[b] Wines with scores of 65% and higher.
[c] Includes small percentage of active amyl acetate.

Purification of compounds: The esters were purified with the aid of a Perken-Elmer 900 preparative gas chromatograph. Purification was done by fractionation on a 3 m × 6.4 mm stainless steel column packed with Chromosorb W AW DMCS, 60 to 80 mesh which was coated with 10% FFAP. Fractionation was continued until the threshold value in a wine residue medium, as determined with the multiple difference method used by Clapperton (3), was of the same order of magnitude as that determined by de Wet (5) with the triangular method in a similar medium. Isobutyl and isoamyl alcohol were purified in the same way.

Preparation of the medium: Dry white wines of the cultivars Thompson Seedless, Chenin blanc and Muscat of Alexandria were extracted with Freon 11 to remove the typical fermentation bouquet. The ratio of wine to Freon was 9:1, but the Freon was divided into five equal volumes and used in separate repetitive extractions in a separatory funnel. The liquid phase was evacuated to 2.7 to 4 kPa (20 to 30 mm Hg) at room temperature with the aid of a water aspirator until no Freon was detectable. At this stage, usually after two hours, the neutral wine medium was introduced into a container filled with carbon dioxide and stored under a carbon dioxide blanket for two to three days before it was used.

Organoleptic odor evaluation of samples: A panel of 11 to 14 experienced wine tasters was used and all odor evaluations were performed in duplicate or triplicate between 8:30 AM and noon in a tasting room which is equipped with tasting booths and in which the temperature is kept constant at 20°C. A modified hedonic scale was used for this purpose and all the required information, which includes the code number of judge, the code number of the sample, the score for odor quality and the score for odor intensity, was entered directly on a punch card. The odor intensity and quality scale allowed the allocation of a minimum of one point (very weak/very poor) and a maximum of nine points (very strong/very good) with a median of five points (moderate/fair). The coded samples were served to each judge in a randomly selected order. The significance of the differences between the average scores of the samples was determined by an analysis of variance using a Univac computer and the "statistical packages for the social sciences" (12).

Wine analysis: The treated as well as the untreated wine samples were analyzed for individual esters and higher alcohols according to the gas chromatographic method of Rapp (13) as modified by Marais (10). The purity of each ester was also checked gas chromatographically. Routine wine analyses, e.g., alcohol (7), free and total sulfur dioxide (1), volatile acidity (7), pH and total titratable acidity (1), total esters (7) and total higher alcohols (1) were determined on all samples.

RESULTS AND DISCUSSION

Purity and threshold values of esters: The percentage purity and the threshold values of the esters used in this study are given in Table 2. Both sets of values indicate satisfactory purity. In addition the odor of each ester was characteristic and in accordance with odor descriptions (11).

Table 2. Purity and threshold values of esters and higher alcohols.

Component	% purity[a]	Threshold value mg/L[b]
Isoamyl acetate	99.42	0.16
n-Hexyl acetate	99.29	0.67
2-Phenethyl acetate	99.24	1.8
Ethyl acetate	99.75	12.3
Ethyl-n-hexanoate	99.76	0.08
Ethyl-n-octanoate	99.61	0.58
Ethyl-n-decanoate	98.69	0.51
Isobutanol	99.37	228.0
Isoamyl alcohol	98.50	14.5

[a] Determined gas chromatographically.
[b] According to de Wet (5).

The effect of extraction with Freon 11 on wine composition: Routine analyses of a Thompson Seedless wine prior to and after extraction with Freon 11 are presented in Table 3. The analyses show that, although the wine was effectively deodorized, its composition was, with the exception of total esters, not drastically affected. The free and total sulphur dioxide contents remained unchanged, whereas the volatile acidity and the total higher alcohol contents were slightly reduced. The concentrations of individual esters and higher alcohols presented in Table 4 confirm the above-mentioned tendencies with respect to these compounds. It also appears that the reduction of esters in the Chenin blanc and Muscat of Alexandria wines was greater than in the Thompson Seedless wine. An organoleptic evaluation of the extracted wines confirmed that, although the products had rather low intensity and neutral odors, they were still vinous, uncontaminated, and unspoiled. This marked decrease in typical bouquet and ester content is indicative of the possible contribution of the latter to the former.

Table 3. Composition of two white table wines prior to and after extraction with Freon 11.

Sample	Alcohol (vol %)	SO_2 (mg/L) Free	SO_2 (mg/L) Total	pH	Total acid (g/L)	Volatile acidity (g/L)	Total esters (mg/L)	Total higher alcohols (mg/L)
Original wine A[a]	13.91	25	96	3.41	4.60	0.26	111.9	160
Extracted wine A	13.89	25	102	3.39	4.60	0.18	23.6	139
Original wine B[a]	13.92	29	95	3.36	4.50	0.23	—	—
Extracted wine B	13.69	26	93	3.35	4.40	0.19	—	—

[a] Thompson Seedless.

Table 4. Concentrations of individual esters and higher alcohols in different cultivar wines prior to and after extraction with Freon 11.

Sample	Concentration (mg/L)[a] Ethyl acetate	Iso-amyl acetate	n-Hexyl acetate	2-Phen-ethyl acetate	Ethyl-n-hexa-noate	Ethyl-n-octa-noate	Ethyl-n-deca-noate	Iso-buta-nol	Iso-amyl alcohol	n-Hexa-nol	2-Phen-ethanol
Thompson Seedless											
Before extraction	29.7	1.83	0.07	0.07	0.74	1.19	0.36	21.9	131	0.85	9.16
After extraction	25.8	1.01	traces	0.02	0.33	0.54	0.16	21.1	119	0.77	7.56
Extract + esters[b]	19.3	5.06	0.30	traces	0.59	1.42	0.26	18.4	114	0.74	8.47
Chenin blanc											
Before extraction	56.9	3.74	0.27	0.36	0.58	1.30	0.49	20.9	104	1.28	9.15
After extraction	26.6	0.26	traces	0.35	0.03	0.18	traces	19.5	92.5	0.79	8.88
Muscat of Alexandria											
Before extraction	51.7	3.27	0.19	0.19	0.52	1.15	0.40	14.8	96.5	0.81	8.28
After extraction	23.7	0.27	traces	0.21	traces	traces	traces	12.6	77.0	0.36	6.63

[a] Average of duplicates analyzed at different times.
[b] According to Table 1, Col. 6.

The effect of a selected combination of pure esters on the quality and intensity of the odor: In order to determine the influence of the technique of extraction on odor and to ascertain to what extent the addition of the selected combination of six esters to the extracted Thompson Seedless wine would compensate for the odor losses during extraction, both treated and untreated samples were evaluated with the aid of the 9-point hedonic score card. In order to also determine the effect of the time interval between the addition of esters and the evaluation of the samples, the latter were stored for seven days at $-4°C$ before evaluation. The low storage temperature was selected to restrict the possible hydrolysis of esters.

The average scores for these samples are given in Table 5. It is clear that extraction with Freon caused a highly significant reduction in intensity and quality of the odor. The addition of a mixture of esters to the wine residue at levels equivalent to those normally produced by yeasts leads to a highly significant increase in intensity and quality of the odor. These effects were not influenced by a storage period of seven days at $-4°C$.

The average points awarded to the wine residue after addition of esters were of the same order of magnitude as for the original wine. It therefore appears that this combination of esters at the particular dosage level was sufficient to compensate for the marked loss in odor by extraction with Freon 11. Although it is possible that other compounds which were not appreciably affected by the extraction process, e.g., ethyl acetate, higher alcohols, etc., may interact with these esters and therefore contribute to the overall odor of a wine, their positive contribution to odor as such appears to be relatively small. Somewhat disappointing, however, is the rather high magnitude of the standard deviations for both quality and intensity scores.

Table 5. The effect of the addition of a combination of acetic acid esters and ethyl esters on the odor quality and intensity of a Freon extracted Thompson Seedless wine.

Treatment	Odor quality Max: 9 points Mean[a]	S[b]	Odor intensity Max: 9 points Mean	S
Untreated wine	5.45	1.70	6.15	1.72
Extracted wine	4.45	1.73	4.33	1.83
Extracted wine + esters[c]	5.55	1.50	5.85	1.64
Untreated wine, after 7 days[d]	4.82	1.38	5.27	1.42
Extracted wine, after 7 days	3.61	1.48	3.88	2.06
Extracted wine + esters, after 7 days	5.67	1.34	5.39	1.48
F-value	9.003		8.743	
LSD ($p < 0.01$)	0.97		1.08	
LSD ($p < 0.05$)	0.74		0.82	

[a] Eleven judges, three replicates.
[b] Standard deviation.
[c] Esters given in Table 1, Col. 6.
[d] Stored at $-4°C$.

The effect of variation of combinations and concentrations of esters on quality and intensity of the odor: The fact that the combination of six esters markedly improved odor quality and intensity and greatly compensated for the loss in odor during extraction with Freon 11 does not exclude the possibility that a similar effect could be achieved with a smaller number of esters. In order to establish such a possibility, the effects of the ethyl esters of the main longer carbon chain fatty acids, viz, n-hexanoic, n-octanoic and n-decanoic acid, as well as the effects of the acetates, viz, isoamyl, n-hexyl and 2-phenethyl acetate, were compared with those of a combination of both groups. The effects of increased levels of each group of esters were also investigated. The average scores for these samples are given in Table 6. Addition of these groups of esters to the extracted wine revealed the following: at the preselected dosage level the ethyl esters as a group did not improve odor quality significantly, whereas the acetates, as well as the combination of acetates and ethyl esters, resulted in a highly significant improvement. However, at double the normal dosage level, the ethyl esters also improved odor quality highly significantly.

Doubling of the concentrations of the acetates and combination of acetates and ethyl esters caused no additional significant improvement. The average score for odor was, however, appreciably higher in the case of the combination of all six esters than with the smaller groups of either acetates or ethyl esters. It is also interesting to note that at the same dosage levels, the odor intensity of the samples to which the acetate-ester combination had been added was appreciably higher than in the case of the other samples.

Table 6. The effect of ethyl esters and acetates separately and combined on odor quality and intensity.

Treatment	Odor quality Max: 9 points		Odor intensity Max: 9 points	
	Mean[a]	S[b]	Mean	S
Untreated Chenin blanc wine	5.48	1.68	6.00	1.63
Untreated Thompson Seedless wine	3.52	1.53	5.34	1.23
Extracted Thompson Seedless wine	3.10	1.47	3.83	1.51
Extracted wine + ethyl esters[c]	3.90	1.54	5.03	1.88
Extracted wine + ethyl esters (× 2)[d]	4.59	1.72	5.72	1.79
Extracted wine + acetates[c]	4.76	1.86	6.10	1.82
Extracted wine + acetates (× 2)	4.79	1.92	6.97	1.57
Extracted wine + ethyl esters + acetates	4.45	1.80	4.48	1.72
Extracted wine + ethyl esters (× 1.5) + acetates (× 1.5)	4.40	1.40	5.87	1.55
Extracted wine + ethyl esters (× 2) + acetates (× 2)	5.31	1.93	6.31	1.65
F-value	5.234		10.966	
LSD ($p < 0.01$)	1.17		1.12	
LSD ($p < 0.05$)	0.89		0.85	

[a] First evaluation, 15 judges; second evaluation, 14 judges.
[b] Standard deviation.
[c] Ethyl esters and acetates as in selected combination in Table 1, Col. 6.
[d] Double dosage = (× 2).

It therefore appears that the odor intensity of the group of ethyl esters might have suppressed the intensity of the acetates. A similar, but not significant, tendency is reflected by the corresponding scores for odor quality. Similar effects were obtained when isoamyl acetate, instead of the acetate ester mixture (in which isoamyl acetate was the abundant ester), was added to a Freon extracted Thompson Seedless wine with, or without, the same group of ethyl esters at the same concentration levels (16). However, the positive odor quality contribution of the ethyl esters in combination with acetates is revealed only at the higher dosage level. Therefore, although the odor improvement by the ethyl esters appears to be more subtle in contrast to that of the acetates, it appears to make an appreciable contribution to the overall odor quality.

Influence of wine medium: A fundamental approach in this investigation was first to determine the contribution of odors of fermentation products in as uncomplicated a wine medium as possible; in other words, the medium should not have a distinctive aroma. In order to establish the extent to which fermentation esters contribute to the odor and general quality of wines with more complexed aromas, similar evaluations were repeated on Chenin blanc and Muscat of Alexandria wines. These results are given in Table 7. The reduction in odor quality by Freon extraction in both cultivar wines was highly significant. However, the odor reduction was appreciably smaller in the case of the Muscat of Alexandria wine. In fact, the extracted product still had a distinct muscat character, apparently because the terpenoids responsible for this aroma (4,15,21) were not extracted completely. In both cases the addition of the preselected ester mixture to the Freon extracted wines produced highly significant increases in odor quality and intensity, the latter occurring particularly in the case of double dosages. These additions of esters to a large extent compensated for the losses in odor by extraction. However, in the Muscat of Alexandria wine this compensation was less pronounced than in the Chenin blanc wine as is indicated by the average scores. This is apparently due to the fact that a portion of the muscat aroma constituents was removed by extraction, but was not included with the added mixture of esters.

It therefore appears that the standard ester mixture in fact contributed to wine odor quality and intensity, regardless of the dry wine medium and even in the presence of a distinct muscat aroma.

Table 7. The effect of additions of a mixture of ethyl esters and acetic acid esters on the odor quality and intensity in Freon extracted Chenin blanc and Muscat of Alexandria wines.

Treatment	Odor quality Max: 9 points		Odor intensity Max: 9 points	
	Mean[a]	S[b]	Mean	S
Chenin blanc				
Untreated wine	5.45	2.30	6.68	1.17
Freon extracted wine	2.77	1.34	5.09	2.07
Extracted wine + esters[c]	4.41	1.14	5.09	1.38
Extracted wine + esters (× 2)[d]	5.59	1.65	6.77	1.38
Muscat of Alexandria				
Untreated wine	7.36	1.36	7.82	1.14
Freon extracted wine	5.50	1.68	5.77	1.31
Extracted wine + esters	6.68	1.59	6.64	1.65
Extracted wine + esters (× 2)	6.30	1.43	7.05	1.36
F-value	17.565		9.62	
LSD ($p < 0.01$)	1.24		1.13	
LSD ($p < 0.05$)	0.94		0.86	

[a] Eleven judges, two replicates.
[b] Standard deviation.
[c] Esters given in Table 1, Col. 6.
[d] Double dosage = (× 2).

The effect of single esters on the quality and intensity of the odor: Since some of the esters of white table wines are present at relatively higher levels than others, their individual contributions to odor were investigated. In the case of the preselected combination of six esters, each of them was in turn omitted from the combination. In addition the concentrations of isoamyl acetate and ethyl-n-octanoate, both of which are believed to be key fermentation volatiles with respect to wine bouquet, were increased to levels above those in the preselected combination. These ester combinations were evaluated organoleptically after addition to the Freon extracted Thompson Seedless wine. The results of this evaluation are given in Table 8.

Table 8. The effect of individual esters on odor quality and intensity.

Treatment	Odor quality Max: 9 points		Odor intensity Max: 9 points	
	Mean[a]	S[b]	Mean	S
Extracted wine[c] + esters[d] (EWE)	5.05	1.50	5.00	1.48
EWE without isoamyl acetate	5.00	1.48	5.64	1.71
EWE without n-hexyl acetate	5.50	1.41	5.64	1.53
EWE without 2-phenethyl acetate	5.05	1.53	5.64	1.26
EWE without ethyl-n-hexanoate	6.00	1.23	5.27	1.45
EWE without ethyl-n-octanoate	5.64	1.53	5.45	1.62
EWE without ethyl-n-decanoate	5.09	1.48	4.95	1.59
EWE + 2 mg/L isoamyl acetate	5.64	1.26	6.00	1.38
EWE + 1.5 mg/L ethyl-n-octanoate	5.36	1.40	5.32	1.64
F-values	1.046		1.517	
D-values ($p < 0.05$)	1.31		1.42	

[a] Eleven judges, two replicates.
[b] Standard deviation.
[c] Thompson Seedless dry white wine.
[d] Esters: 4.5 mg/L isoamyl acetate
0.3 mg/L n-hexyl acetate
0.3 mg/L 2-phenethyl acetate
1.0 mg/L ethyl-n-hexanoate
1.0 mg/L ethyl-n-octanoate
0.4 mg/L ethyl-n-decanoate.

In no case did the exclusion of a single ester from the preselected combination or the increase in concentration of either isoamyl acetate or ethyl-n-octanoate cause any significant difference in odor intensity or quality. These results support those of Keith and Powers (8) who varied the concentration of one component in a mixture of six, but could not demonstrate variations in organoleptic evaluations. It therefore seems that although each of the individual esters is present in above-threshold concentrations, the absence of one from the group is masked by the odors of the remaining ones, especially if they have similar odors and additive effects. However, it should be pointed out that isoamyl acetate at extraordinary high levels, as was often found in red table wines made from Pinotage grapes, makes a very pronounced contribution to the fermentation bouquet of such wines (18). In only isolated cases was isoamyl acetate found to be present in white table wines at levels above 10 mg/L, in which cases the wine bouquet was similar to that of the typical Pinotage fermentation bouquet (19).

It is generally accepted that excessive quantities of ethyl acetate have negative quality effects in wine, whereas at lower levels it is believed to contribute positively towards wine quality (2). The effects of the addition of ethyl acetate in combination with the selected mixtures of esters (Table 1) to the Freon extracted Thompson Seedless wine are shown by the data in Table 9. It is clear that the addition of ethyl acetate at a level of 50 mg/L had no significant effect on the quality and intensity of the odor, but additions of 100 and 200 mg/L caused highly significant decreases in odor quality and increases in odor intensity.

Table 9. The effect of ethyl acetate on odor quality and intensity.

Treatment	Odor quality Max: 9 points		Odor intensity Max: 9 points	
	Mean[a]	S[b]	Mean	S
Extracted wine + esters (× 2)[c] (EWE × 2)	5.18	1.65	6.18	1.62
EWE × 2 + 50 mg/L ethyl acetate	5.00	1.38	6.14	1.46
EWE × 2 + 100 mg/L ethyl acetate	3.18	2.13	7.18	1.47
EWE × 2 + 200 mg/L ethyl acetate	1.41	1.10	8.41	0.73
F-value	26.585		13.512	
LSD ($p < 0.01$)	1.28		1.08	
LSD ($p < 0.05$)	0.97		0.82	

[a] Eleven judges, two replicates.
[b] Standard deviation.
[c] Thompson Seedless wine + double dosage of selected combination of esters (Table 1, Col. 6).

The actual ethyl acetate contents of these samples ought to be increased by approximately 25 mg/L, which was the average content of this ester in the Thompson Seedless wine after extraction. It therefore follows that concentrations of up to 75 mg/L ethyl acetate had no significant effects on odor quality and intensity, but at levels between 75 and 125 mg/L its negative quality effects became significant in a dry white wine medium. This represents a level of at least six times its threshold value in a deodorized wine medium.

The effect of isobutyl and isoamyl alcohol on the quality and intensity of the odor: In view of the fact that higher alcohols are present in reasonably large quantities and are generally believed to have negative quality effects at high concentrations (2), the contribution of added isobutyl and isoamyl alcohol to odor quality and intensity was determined. For this purpose increasing quantities of these alcohols at levels equivalent to those normally present in wine were added to the Freon extracted Thompson Seedless wine, to which the selected combination of esters had previously been added. The average scores for these samples are given in Tables 10 and 11. Although there were no significant differences in the odor quality and intensity of samples which contained isoamyl alcohol at levels 8 to 18 times its threshold value in a deodorized wine medium (5), the samples which contained the highest levels of this alcohol had lower average scores. Similarly, there were no significant differences between samples to which different levels of isobutyl alcohol were added.

It therefore appears that the suspected negative quality effects of higher alcohols are not noticeable at the levels normally found in dry white wines when made from clarified juice and fermented at relatively low temperatures.

CONCLUSION

The results of this investigation emphasize the im-

Table 10. The effect of isoamyl alcohol on the odor quality and intensity.

Treatment	i-Amyl alcohol mg/L	Odor quality Max: 9 points		Odor intensity Max: 9 points	
		Mean[a]	S[b]	Mean	S
Extracted wine[c] + esters[d] (EWE)	119	4.69	2.14	4.97	1.82
EWE + 30 mg/L i-amyl alcohol	149	4.03	1.57	4.55	1.62
EWE + 90 mg/L i-amyl alcohol	209	4.03	1.59	4.90	1.95
EWE + 150 mg/L i-amyl alcohol	269	3.90	1.76	5.03	1.70
F-value		1.164		0.422	

[a] Fourteen judges, two replicates.
[b] Standard deviation.
[c] Thompson Seedless wine extracted with Freon 11.
[d] Double dosage of selected combination of esters (Table 1, Col. 6).

Table 11. The effect of isobutyl alcohol and isoamyl alcohol on the odor quality and intensity.

Treatment	Odor quality Max: 9 points		Odor intensity Max: 9 points	
	Mean[a]	S[b]	Mean	S
Extracted wine + esters (× 2)[c]	5.18	1.65	6.18	1.62
EWE × 2 + 150 mg/L isoamyl alcohol	4.50	1.82	6.55	1.22
EWE × 2 + 20 mg/L isobutyl alcohol	5.14	1.36	5.68	1.81
EWE × 2 + 40 mg/L isobutyl alcohol	4.77	1.81	5.55	1.92
EWE × 2 + 100 mg/L isobutyl alcohol	5.00	1.41	5.86	1.49
F-value	0.741		1.344	

[a] Eleven judges, two replicates.
[b] Standard deviation.
[c] Thompson Seedless wine extracted with Freon 11 + double dosage of selected combination of esters (Table 1, Col. 6).

portant quality contribution of certain fatty acid esters in relatively neutral wines, as well as wines with more pronounced aromas. Although it is known that some components have more pronounced odors than others, the more complex combination of esters were shown to improve the quality of the odor to a greater extent than less complex combinations. It also is evident that at the relatively low concentrations in which ethyl acetate, isobutyl alcohol and isoamyl alcohol are normally present in white table wines made from clarified juice fermented at 12 to 15°C, their contribution to the quality of the odor is relatively small compared to that of the selected combination of esters. However, at relatively high levels, ethyl acetate had a highly significant negative quality effect on the odor, whereas isoamyl alcohol at relatively high levels only caused a slight, insignificant decrease in the quality of the odor. Relatively high levels of isobutyl alcohol had no quality and intensity effects on the odor of the product.

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