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# The quality of white wines fermented in Croatian oak barrels

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**Abstract**

Croatian barrels are traditionally made of the oak wood from the region of Slavonia, but its influence on wine quality has not been explored scientifically. This paper is a first investigation of Croatian barrique barrels and their influence on wine quality. Chardonnay and Sauvignon musts were fermented in new light and medium-toasted Croatian barrique barrels (225 l) and in steel tanks of the same volume. Chemical analysis of phenolic acids and phenolic aldehydes were made by HPLC just after fermentation. The wines were sensory tested by the descriptive method and the O.I.V./U.I.O.E. method by 100 positive points. The concentrations of phenolic compounds varied in the wines compared. Sauvignon wines generally had some higher total quantities of phenolic acids when compared with Chardonnay wines. Our results indicated that sensorial characteristics of produced wines were modified, probably due to the wood-derived compounds.


*Keywords:* Barrique; White wines; Oak phenols; Sensory properties

## 1. Introduction

One of the practices used to intensify the aroma and flavour characteristics of white wines is to ferment the must in oak barrels, and Chardonnay is one of the most suitable varieties for this. Wines produced by fermentation and maturation in oak barrels have different flavour characteristics to those, which have undergone barrel maturation only after fermentation in stainless steel. One reason for this phenomenon is that actively growing yeasts are capable of transforming volatile flavour components, extracted from oak wood, into other volatile metabolites (Humphries, Jane, & Sefton, 1992). It is of considerable interest to winemakers and coopers to know that oakwood obtained from different species or of the same species from different sites contains varying amounts of important aromatic aldehydes (Miller, Howell, Michaelis, & Dickmann, 1992). The accumulation of oak volatile compounds in wine during storage in oak barrels can depend on many factors (Spillman, Iland, & Sefton, 1998). Although hundreds of volatile compounds have been identified in untoasted oakwood, relatively few volatiles, including vanillin, are present in significant amounts (Spillman, Pollnitz, Liacopoulos, Skouromounis, & Sefton, 1997). The degradation of oakwood lignin generates a variety of volatile phenols, which can be extracted from the wood into the wine. The most abundant of these compounds are vanillin and syringaldehyde. Vanillin, present in all kinds of wood, is the most important because of its characteristic scent of vanilla. It can be used as an indicator of fermentation and aging in oak barrels (Sefton, Francis, & Williams, 1989). In the white wines this apparently occurred only during barrel fermentation and maturation on lees (Puech, 1987). The oak species most commonly used in barrel making are *Quercus alba*, also known as American oak, *Quercus petrea* and *Quercus robur* which grow in Europe, the most popular being French oak (Humphries et al., 1992). Croatian oak is famous worldwide and is traditionally exported, but its influence on wine has never been scientifically explored.

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Because of that in the period from 2000 to 2002 the influence of fermentation on the quality of wine from French and Croatian oak barrels was investigated and the results suggested no significant differences between the tested oak barrels. On the contrary, wines from Croatian oak barrels were in some cases even better than wines from French oak barrels (Herjavec, 2002).

The objective of this study was to describe the differences in chemical composition and sensory properties of the Chardonnay and Sauvignon wines produced in new light and medium-toasted Croatian barrique barrels and their comparison with the wines of the same varieties fermented in steel tanks.

## 2. Material and methods

### 2.1. General

Chardonnay and Sauvignon wine grapes obtained from the continental wine region of Croatia were harvested during the 2001 season. The free-run juice was treated with 50 mg/l $SO_2$ and allowed to settle overnight. The juice was racked and the must distributed into new barrique barrels (*Q. petrea*, light and medium-toasted). Must alcoholic fermentation was carried out with selected *Saccharomyces paradoxus* RO 54 strain obtained from the Department of Microbiology, Faculty of Agriculture, University of Zagreb. Yeast strain culture was preincubated in sterilized grape must for 48 h at 25 °C and finally inoculated at $8 \times 10^6$ CFU/ml. Sugar degradation in all wines was completed in 30 days. The samples of all barrels and steel fermented wines were chemically and sensory analyzed.

### 2.2. Chemical analyses

Routine analyses of basic components in the must and wines were made using standard methods (Majdak, Herjavec, Orlic, Redzepovic, & Mirosevic, 2002). The phenolic acids and phenolic aldehydes were analyzed by the HPLC method (Silva, Mazzoleni, & Parodi, 1999).

### 2.3. Sensory analysis

The wines were subjected to sensory evaluation by the 100-point O.I.V./U.I.O.E method (Crettenand, 1999) and by descriptive analyses (Lindblom, 1999), with a panel of 13 judges. Analyses of variance were run on each descriptor and significant differences among the samples observed as shown in Table 1.

Table 1
Chemical composition of Chardonnay and Sauvignon musts

| Compound | Year | |
|---|---|---|
| | Chardonnay Plesivica vineyard 2001 | Sauvignon Kutjevo vineyard 2001 |
| $^0$Oe | 97 | 91 |
| Total acidity[a] (g/l) | 7.8 | 8.2 |
| NTU[b] | 282 | 190 |
| PH | 3.10 | 3.21 |

[a] As tartaric acid.
[b] Nephelometric turbidity units.

## 3. Results and discussion

### 3.1. Chemical composition

The results presented in Table 2 show that *S. paradoxus* strain 54 metabolised the total must sugar content, confirming its good fermentation abilities, as reported in earlier experiments (Majdak et al., 2002). There were no differences in simple chemical composition between the barrel and inox-fermented wines. In Table 3 initial results are reported about phenolic compounds in the wines fermented in Croatian barrique barrels. The barrels used in this experiment were from the same cooper, so that the sources of this variation could lie in the inherent variability of all biological systems, including oak trees, and in the low reproducibility of traditional cooperage practices such as open-air seasoning and oak-fire toasting. Furthermore, since the cooper determines the toast level visually and since no uniform objective definition of the various toast

Table 2
Chemical composition of Chardonnay and Sauvignon wines

| Compound | Chardonnay | | | Sauvignon | | |
|---|---|---|---|---|---|---|
| | Inox | Light | Medium | Inox | Light | Medium |
| Alcohol (vol%) | 12.7 | 13.0 | 12.9 | 12.4 | 12.7 | 12.6 |
| Reduc. sugar (g/l) | 3.0 | 1.75 | 3.25 | 1.6 | 1.0 | 1.0 |
| Total acidity[a] (g/l) | 5.4 | 5.8 | 5.9 | 5.2 | 5.5 | 6.3 |
| Volatile acidity[b] (g/l) | 0.40 | 0.46 | 0.46 | 0.34 | 0.45 | 0.42 |
| pH | 3.48 | 3.37 | 3.38 | 3.51 | 3.41 | 3.35 |
| Ash (g/l) | 2.37 | 2.30 | 2.39 | 2.10 | 2.12 | 2.23 |

[a] As tartaric acid.
[b] As acetic acid.

Table 3
Phenolic compounds in Chardonnay and Sauvignon wines in mg/l

| Compound | Chardonnay | | | Sauvignon | | |
|---|---|---|---|---|---|---|
| | Inox | Light | Medium | Inox | Light | Medium |
| 3-Hydroxybenzoic acid | 0.41 | 0.24 | 0.52 | 0.35 | 0.33 | 1.32 |
| 4-Hydroxybenzoic acid | 1.29 | 0.8 | 1.74 | 0.48 | 1.33 | 3.06 |
| Caffeic acid | 0.40 | 0.29 | 0.20 | 1.87 | 0.81 | 0.30 |
| Chlorogenic acid | 0.60 | 2.90 | 2.35 | 1.96 | 1.52 | 1.87 |
| Coumaric acid | 0.70 | 0.66 | nd | 0.57 | 0.42 | 0.25 |
| Ferulic acid | nd | nd | nd | 0.40 | 0.21 | 0.30 |
| Gallic acid | 1.48 | 1.26 | 1.85 | 3.73 | 3.12 | 1.70 |
| Syringic acid | 0.51 | 2.10 | 1.20 | 0.16 | 1.16 | nd |
| Vanillic acid | 0.62 | 1.02 | 1.38 | nd | 1.73 | 0.63 |
| ∑acids | 6.01 | 9.27 | 9.24 | 9.52 | 10.63 | 9.43 |
| Syringaldehyde | 1.97 | 2.96 | 2.1 | 0.89 | 2.90 | 1.23 |
| Vanillin | nd | 0.36 | 0.32 | nd | 0.73 | 0.60 |
| ∑aldehydes | 1.97 | 3.32 | 2.42 | 0.89 | 3.63 | 1.83 |

levels exists, barrels of the same stated toast level made by the same cooper can vary considerably in their actual toast level (Towey & Waterhouse, 1996). In addition to that, it is well known that there is a high degree of variation in the oak-related aromas of wines aged in supposedly similar barrels. Concentrations of lignin-derived aldehydes – vanillin, sinapaldehyde, syringaldehyde, coniferaldehyde, vanillic and syringic acids generally increased with the heating time (Mosedale & Ford, 1996). However, in our case we observed a large decrease in syringic acid and syringaldehyde, whereas in the vanillin concentration there was no marked change. Vanillin has a level of organoleptic perception of 0.5 mg/l (Sefton et al., 1989). This level is close to the content found in some wines, especially in those aged in 225-l barrels. Our results confirmed the importance of vanillin as an indicator of keeping wines in oak barrels. On the basis of presented results, as shown in Table 3, it seems that the toasting level had no influence on vanillin content but some differences were observed between the Chardonnay and Sauvignon wines. Inox-fermented wines had no vanillin, whereas only Sauvignon barrel-fermented wines contained a concentration higher than the organoleptic perception level. Syringaldehyde has a higher level of organoleptic perception of 15 mg/l. This content, however, never occurred in the wines tested and is unlikely to play a role in organoleptic perception, especially because of its lack of characteristic odour (Puech, 1987). But, it is possible that the wood – imparted compounds, while occurring below their detection threshold, interact synergistically with flavours in the wine, thus yielding a detectable change when none would be predicted based solely on concentration data (Miller et al., 1992). A comparison of Chardonnay and Sauvignon wines aged in 225 l barrels showed that Sauvignon wines generally had some higher total quantities of phenolic acids. Vanillin content was also higher in Sauvignon wines. Results presented in Table 3 also seemed to indicate that Sauvignon had extracted more phenolic compounds from the oakwood than Chardonnay.

### 3.2. Sensory properties of wines

Wines extract from oakwood volatile flavour components, which enhance the intensity and complexity of the wine flavour (Silva et al., 1999). Barrel fermentation of Chardonnay wine is one of many options available to the winemaker in adding another dimension to wine. However, the use of this technology in the production of Sauvignon wines is not so common. Our investigation has shown a positive influence on the Sauvignon wine quality. Presented results indicate that the sensorial characteristics of barrel-aged wines were modified, due to the wood-derived compounds. These wines manifested roundness in taste with a complex retro nasal aroma. The results of the 100-point method show the similar quality of wines produced in light and medium-toasted barrels used in this experiment. According to the descriptive analysis, marked differences were observed in the fruity aroma of Chardonnay wines. Aging in medium-toasted barrels resulted in a more smoky, roasted and raw oak flavour, whereas light toasting resulted in a more fruity aroma. Sauvignon wines had complex retro nasal aroma, but as some of the tasters evaluated, these wines had somewhat less pronounced varietal flavours. The sensory impact of vanillin is likely to vary not just between individuals but may also depend on the presence of other wine components which could modify, mask or enhance its aroma and taste properties. It can be

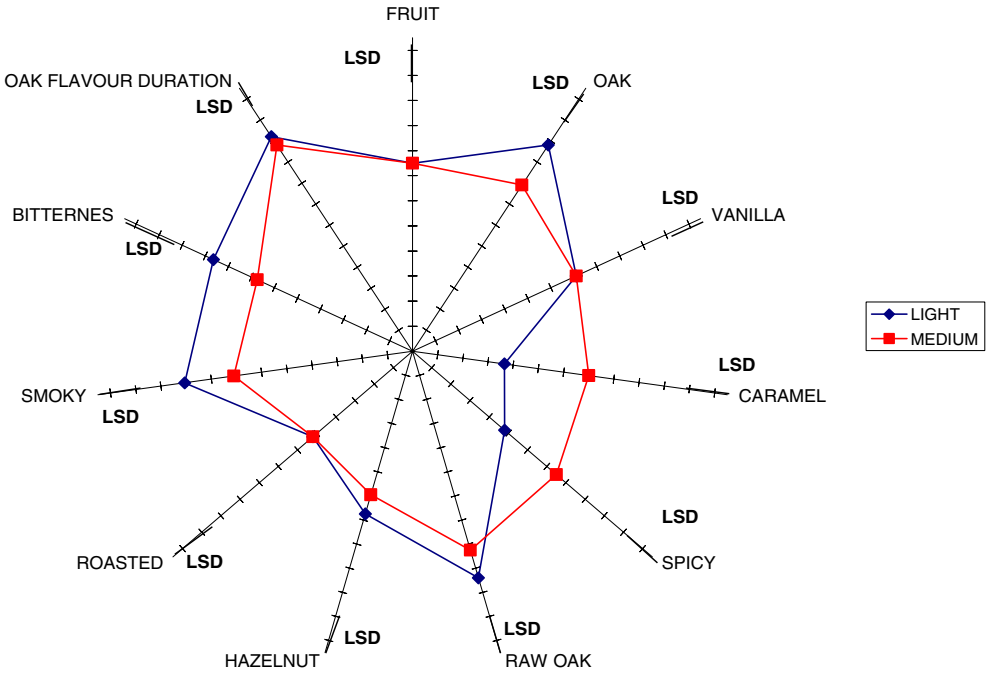


Fig. 1. Sauvignon aroma descriptive profiles.

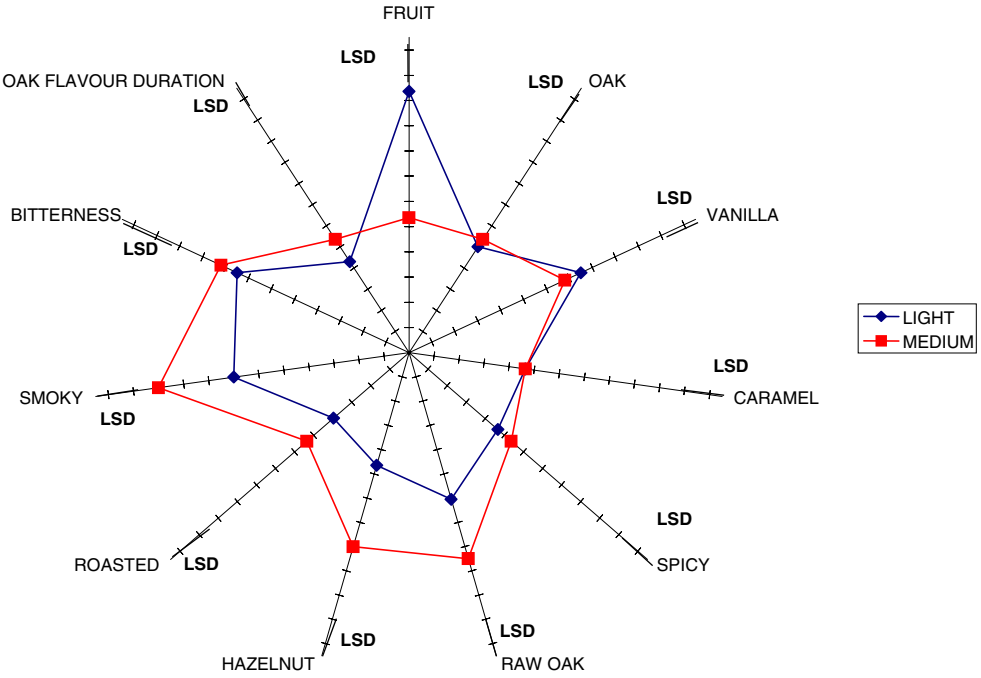


Fig. 2. Chardonnay aroma descriptive profiles.

Table 4
Results of Sauvignon wine testing by 100-point O.I.V./U.I.O.E. method

| | Light | Medium | Inox |
|---|---|---|---|
| Total score | 81.4 | 82.3 | 79.1 |

Table 5
Results of Chardonnay wine testing by 100-point O.I.V./U.I.O.E. method

| | Light | Medium | Inox |
|---|---|---|---|
| Total score | 81.9 | 80.5 | 78.5 |

assumed that the strong varietal character of Sauvignon wines masked oak flavour aromas. Even though the vanillin concentration in these wines was above threshold levels, its sensory impact was diminished. Fig. 1 shows that for the Sauvignon wines two of the eleven sensory attributes used by the panel were significantly altered by toasting, which elicited significantly higher caramel and spicy attributes of the sample. Fig. 2 demonstrated for the Chardonnay wines that toasting level significantly enhanced four of the eleven sensory attributes, but significantly reduced the perceived fruit aroma intensity. Chardonnay wines from medium-toasted barrels had a longer lasting smoky, raw oak, hazelnut and oak flavour. The results from panel tasting by 100-point O.I.V/U.I.O.E. shown in Tables 4 and 5 also confirmed better quality of barrel fermented Chardonnay and Sauvignon wines compared to inox wines.

## 4. Conclusion

Results of this study indicate that fermentation in Croatian oak barrels positively influence the quality of Chardonnay and Sauvignon wines. In comparison with inox-fermented wines, these wines were characterized by a more complex flavour and aroma intensity. Barrel fermentation had a varying influence on varietal aroma, which was less pronounced in Sauvignon wines. These results show the complexity of this technology and the need for further research. So an industry based project that investigates the influence of oak origin, seasoning, and barrel maturation has now been under way for some 18 months.

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