A tale of two coopers

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After a single batch of French oak wood was split between two coopers (Schahinger Cooperage and Tonnellerie Ludonnaise) for seasoning and coopering, 24 barrels from each were used for maturing the same wines. The Schahinger Cooperage barrels yielded significantly more intense and ‘preferred’ aromas. Significant composition differences were also found.

Introduction
Some of the influences of seasoning and coopering on the oenological qualities of oak wood have been investigated, particularly by French researchers (e.g. Chatonnet et al. 1989, 1991, 1994a, 1994b, Vivas 1993, Viriot et al. 1994) but also by Francis et al. (1992) and Sefton et al. (1993) who reported results from the early stages of the study discussed below.

This paper summarises the significant wine aroma and volatile composition effects of two proprietary cooperage treatments. With an identical oak wood source and an identical winery usage it has been possible to isolate the effect of the coopers’ practices. The three-year open-air seasoning period at each of the coopers’ premises and the ‘medium toast’ treatment imposed by them are incorporated in these effects.

Materials and methods
The oak used for the barrels was harvested from the Tronçais forest and the Voges and Limousin regions of France. Half of each lot was seasoned in France and coopered by Tonnellerie Ludonnaise while the other half was shipped to, seasoned in and then coopered in Australia by Schahinger Cooperage. A ‘medium toast’ was specified for all barrels. Further details of oak selection and seasoning are given in Sefton et al. (1993).

Twenty four 300 L barrels were constructed by each cooper, nine to be used to store a Chardonnay for 55 weeks, nine for a Cabernet Sauvignon for 93 weeks (both 1991 Coonawarra) and six for a model wine for 93 weeks (details in Spillman et al. 1998b). The Chardonnay and Cabernet Sauvignon wines were made according to the proprietary processes followed at Rouge Homme winery.

The volatile composition of each wine was determined at the end of the storage period using gas chromatography–mass spectrometry (GC–MS). See Sefton et al. (1993) and Spillman et al. (1997, 1998b) for details.

One of the compounds to be discussed, furfural, was found to be unstable (Spillman et al. 1998a) so an estimation of any extracted quantity required a consideration of this compound plus its reduction product, furfuryl alcohol. Thus, the two compounds were summed and are referred to as furfural* in this paper.

The sensory method is described in Spillman et al. (1996) and Spillman (1997). Trained panellists performed separate rankings of descriptors, according to a standard for each. The sessions were arranged in a balanced incomplete block. The panellists were staff or postgraduate students of the Australian Wine Research Institute or of the Department of Horticulture, Viticulture and Oenology, The University of Adelaide.

Treatment effects were explored using factorial analysis of variance, details of which have been reported in Spillman et al. (1997). Only statistically significant effects with no significant interaction effect are discussed in this paper.

Results
The Schahinger barrels yielded wines perceived to be higher in the six attributes listed in Table 1. This was the case among both the Chardonnay and the Cabernet Sauvignon wines for ‘vanilla,’ while the other aroma differences were perceived among only one or the other of the two wines (‘coconut’ among the Chardonnay wines and ‘smoky,’ ‘allspice,’ ‘coffee’ and ‘preference’ among the Cabernet Sauvignon wines).

Table 2 lists the five significant compositional differences. The Schahinger barrels yielded more cis–oak lactone, vanillin and furfural* while the Ludonnaise barrel wines were found to contain higher concentrations of eugenol and 4-ethylphenol. The highly significant differences found for eugenol and cis-oak lactone concur with those found for the wood prior to coopering (Sefton et al. 1993).

The significant effect for vanillin seen in the Cabernet Sauvignon and model wines was a robust effect, only absent from the Chardonnay wine due to the nullifying effect exerted by the alcoholic fermentation which took place in barrel for this wine (Spillman et al. 1997). The effect was established within the first six weeks of maturation in the model wine. Thus, the yeast activity in the Chardonnay wine during

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Wine ¹</th>
<th>Statistical significance ²</th>
<th>Attribute found to be higher in barrels of ²⁰** Schahinger Cooperage</th>
</tr>
</thead>
<tbody>
<tr>
<td>coconut</td>
<td>Chardonnay **</td>
<td>Schahinger Cooperage</td>
<td></td>
</tr>
<tr>
<td>vanilla</td>
<td>Both</td>
<td>Schahinger Cooperage</td>
<td></td>
</tr>
<tr>
<td>coffee</td>
<td>Cabernet **</td>
<td>Schahinger Cooperage</td>
<td></td>
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<tr>
<td>allspice</td>
<td>Cabernet</td>
<td>Schahinger Cooperage</td>
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<tr>
<td>smoky</td>
<td>Cabernet **</td>
<td>Schahinger Cooperage</td>
<td></td>
</tr>
<tr>
<td>preference</td>
<td>Cabernet</td>
<td>Schahinger Cooperage</td>
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</tbody>
</table>

¹Analysis performed on all barrels (9 of Chardonnay and 9 of Cabernet Sauvignon wine per cooper) unless a significant interaction effect was found, in which case subsets were analysed.

²** = p<0.01, * = p<0.05.
effects, one for vanillin and one for furfural*. Both were associated with compounds arising from the coopering process (Spillman 1997). Consequently, these aroma effects are likely to have arisen due to coopering heat influences. These first weeks could erase any vanillin effect that may have been present due to cooper variation.

4-Ethylphenol is usually only present in appreciable quantities in red wine (Chatonnet et al. 1995) so it is not surprising that the effect for this compound was restricted to the Cabernet Sauvignon wine in this study.

Discussion

Seasoning

It is most likely that the seasoning aspects of the treatments have impacted on two of the five composition effects. Both cis-oak lactone and eugenol were present in the wood in substantial quantities before coopering (Selton et al. 1993) and both were associated with oak origin and seasoning variables while showing no association with coopering heat variables (Spillman 1997). Consequently and despite the concurrence of both the seasoning and cooper treatments, any effect for the aromas associated with these compounds is more likely to have arisen due to seasoning location than coopering factors.

Chatonnet et al. (1989) have reported that the oak lactones and eugenol can be affected by coopering heat variation but the range of heating involved in their experiments was apparently much greater than the range imposed in this study. The aromas that are likely to have been at least partially affected by seasoning variables are ‘coconut,’ ‘vanilla’ and ‘preference.’ Each was positively associated with the cis-oak lactone (Spillman 1997). A more intense ‘vanilla’ aroma was also found by Francis et al. (1992) to result from seasoning oak in Australia than from seasoning the same oak in France. Their observation, on wood which had not been subjected to coopering heat, supports the suggestion that seasoning variables have impacted on the ‘vanilla’ effect in the Chardonnay and Cabernet Sauvignon wines. However, ‘vanilla’ in the Cabernet Sauvignon wine was also associated with compounds arising from the coopering processes (Spillman 1997).

To determine whether the effects were more likely results of seasoning conditions, coopering or a combination of these variables, a new experiment, involving tighter control over coopering conditions, is required.

The three other Cabernet Sauvignon wine aromas to have been present due to cooper variation were associated most strongly with compounds arising from the coopering process (Spillman 1997). Consequently, these aroma effects are likely to have arisen due to coopering heat influences.

Coopering

The ‘medium toast’ coopering resulted in two composition effects, one for vanillin and one for furfural*. Both were extracted in greater amounts from the Schahinger barrels but each had a slightly different manner of effect. The vanillin effect was established in the first month or two but the furfural* effect became most apparent in the second year when the amounts extracted from the Ludonnaise barrels began to diminish (Spillman 1997).

Figure 1 illustrates the vanillin extraction curves. The difference between the coopers was established in the early stages. Thereafter, both sets of barrels tended to yield similar amounts. It appears that two different extraction mechanisms may be active for this compound (Spillman et al. 1997). The observations are consistent with the possibility that there was a store of readily extractable vanillin and a second store of less readily extractable vanillin that may have been released by slow acid hydrolysis, for example, from precursors formed during the coopering process. Once the first store of the compound had diminished and the second mechanism became dominant, there was no difference in accumulation rates between the coopers.

W hilst there were significant differences between the two cooperings for vanillin and furfural* there were none for other coopering heat-derived compounds such as guaiacol, a compound known to be found mostly at the surface of the wood. W hat do these results suggest about the two cooperers’ practices?

Chatonnet et al. (1989) have reported that, for ‘medium’ and ‘heavy’ toasted barrels, furfural is formed in higher quantities than in lighter toasted woods. These results are consistent with the observation that there was a store of readily extractable vanillin and a second store of less readily extractable vanillin that may have been released by slow acid hydrolysis, for example, from precursors formed during the coopering process. Once the first store of the compound had diminished and the second mechanism became dominant, there was no difference in accumulation rates between the coopers.
surface than at the surface. Therefore, the quantity of furfural extracted from each barrel by wine may indicate the extent of thermal degradation which has occurred below the wood surface. Guaiacol, on the other hand, has been found to be most concentrated at the surface (Chatonnet et al. 1989) so the amount extracted from each barrel by wine may indicate the extent to which the inside surface of the barrel (to approximately one millimetre) had been thermally degraded.

Figure 2 shows a scatter plot of the relationship between guaiacol and furfural with a line of best fit representing the average proportions of the two compounds that were yielded as the coopering heat progressed from a relatively light toast to relatively heavy toast. When the data were grouped, according to which of the two coopers had made the barrels, a pattern emerged, most of the barrels from each cooper falling on different sides of the line. This illustrates a significant difference in the relative quantities of the two compounds yielded by the different barrels. For a more detailed discussion, see Spillman et al. (1996).

The heat absorbed at two and three millimetres below the wood surface depends, among other things, on the heat absorbed at the surface. Any deviation in sub-surface heat absorption from that typical of the surface heat absorption (estimated by the line of best fit) should reflect, principally, variations in the heat conductivity of the wood and in the intensity and duration of heating.

The closed dots in Figure 2, representing the Schahinger barrels, tended to be located above the line while the open dots, representing the Ludonnaise barrels, tended to be located below it. A plausible explanation for this observation is that a deeper heat penetration per unit of heat applied to the surface was achieved in the Schahinger barrels than those made by Tonnellerie Ludonnaise. However, the deviations may not simply be due to differences in proprietary coopering technique. The location of open-air seasoning also differed. Thus, the moisture content of the wood may have influenced its ability to absorb heat. The France seasoned and coopered wood is likely to have been moister and, therefore, more able to absorb heat before significant thermal degradation occurred.

Mycology
There is one composition effect remaining, one which did not arise directly from seasoning or coopering influences. The higher concentrations of 4-ethylphenol found in the Ludonnaise barrel wines (Table 2) is puzzling because the compound, which possesses a horse or Band-aid like aroma, arises from the activity of Brettanomyces/Dekker sp. yeasts and lactic acid bacteria on the ethyl phenol content of red wines. A.M. J. Enol. Vitic., 46: 463-468.


