Managing eucalyptus aromas

By Dimitra L. Capone, I. Leigh Francis, Markus J. Herderich and Daniel L. Johnson
The Australian Wine Research Institute, PO Box 197, Glen Osmond SA 5064

Mangaging director Dan Johnson

As an investigative story, the hunt for what causes eucalyptus character – and the origin of its aroma compound 1,8-cineole – in wine has the makings of a classic 'whodunnit'. The search for the 'culprit' or 'ally', depending on your preference for or against eucalyptus characters, has thrown up false leads, and an unexpected ending. Studying the origin of 1,8-cineole, AWRI research found that the location and leaves of Eucalyptus trees play a direct role in the concentration of 1,8-cineole and occurrence of the 'eucalypt', 'fresh' or 'minty' characters in wine.

Native to Australia, *Eucalyptus* trees have been planted throughout the world, with large populations of the species now growing in China, India and Brazil: they live on every continent apart from Antarctica. Hardy and resilient, they grow in a range of different climates and environments, providing raw timber and wood pulp, as well as large supplies of eucalyptus essential oil.

It is the oil that matters most to winemakers. Most species of *Eucalyptus* tree contain essential oils in their leaves and, depending on the species, the main component of the oil is a volatile compound called 1,8-cineole, commonly known as eucalyptol. Used as a flavouring agent in a wide range of foods and beverages, as well as being present in a range of therapeutic products, 1,8-cineole can also be found in red wine, where it is responsible for characters described as 'eucalypt', 'camphor', 'fresh' and 'minty'.

For some winemakers these characters are a selling point. Some red wines are well-known for their 'eucalypt' sensory properties and the compound responsible is considered a help, not a hindrance to the winemaker's craft. For other wine producers, however, 'eucalypt' characters are something they prefer to avoid, or at the very least limit through effective management strategies. Discovering the source of 1,8-cineole and understanding how it gets into wine has become a detective story: a case that wine scientists have been determined to solve.

EARLY EVIDENCE

For some time, the origin of 1,8-cineole in wine remained a mystery. Scientists had theories, but none were verified: some researchers believed that 'eucalypt' characters were associated with the proximity of vineyards to *Eucalyptus* trees (Herve *et al.* 2003); others proposed that there were compounds in grape berries that acted as precursors for 1,8-cineole (Farina *et al.* 2005).

Further investigations revealed, however, that the precursor proposal did not account for most of the 1,8-cineole found in wine. Research at the AWRI showed that the precursor compounds were unable to generate high enough levels of 1,8-cineole to reach sensory threshold concentrations (Capone *et al.* 2011). Once this potential source was discounted, the AWRI researchers continued to focus on the proximity of *Eucalyptus* trees to vineyards – historically planted as windbreaks – and whether the location of those trees near vines provided a more likely explanation.

The AWRI also compared red and white wines to see whether there was a clear difference between varieties. A survey of 190 commercially-available Australian wines found eucalyptol, or 1,8-cineole, in significant amounts in red wine varieties only. The survey led to the daily monitoring of two commercial Shiraz ferments from two different winegrowing regions in South Australia throughout fermentation, revealing a continuous increase in the concentration of 1,8-cineole during fermentation that stopped once the wine was drained from the skins. This indicated that the compound was extracted from the grape skins and/or matter other than grapes, commonly known as MOG. How the aroma compound was transferred to grape skins and what is the role of MOG were questions requiring further investigation.

In parallel, consumer studies were carried out by the AWRI sensory team (Osidacz *et al.* 2010) and they found that overall, participants (104 people) had a slight preference for a wine spiked with 4µg/L and 30µg/L of 1,8-cineole compared with an unspiked one, with a sizable cluster of consumers (38%) strongly preferring the wine spiked with 30µg/L of 1,8-cineole. Getting the balance for consumers right requires careful management and to make that happen, winemakers needed to know where the compound 1,8-cineole was coming from. They also needed to know how to control its concentration in wine.

To find out more, the AWRI carried out a detailed study – over three vintages – to investigate the relationship between grape composition and the proximity of vines to *Eucalyptus* trees. The impact of grape leaves, grape stems and leaves from nearby *Eucalyptus* trees were also included in the investigation. The results of this work provided important information that has the potential to change the way that winemakers understand and manage 'eucalypt' characters in red wines.

INVESTIGATIVE TOOLS

Key ingredients for the AWRI study were samples of wine, grapes, grape stems and leaves, as well as samples of *Eucalyptus* leaves. Wine samples from Great Southern, in Western Australia, Yarra Valley, in Victoria, and Coonawarra, in South Australia were supplied by producers.

Healthy Shiraz grapes were hand-harvested from the Padthaway region of South Australia one day prior to commercial harvest. Samples were taken over three vintages (2008, 2009 and 2011), in the same locations each year. To assess the impact of proximity to *Eucalyptus* trees, three samples of grapes were taken from three separate locations within four different rows of the vineyard (providing 36 samples in all for each vintage). The rows were located at different distances from *Eucalyptus* trees: the first row within about five metres and the row furthest away, around 125 metres from the trees.

Grape leaves were also collected from the same spots in 2009 and 2011, and *Eucalyptus* leaves were also taken from the grapevine canopy of the first row in 2011 for analysis and addition to ferment treatments.

Flavour compound traps (consisting of polyethylene sheets) were also installed in a vineyard in 2008 and 2009, to measure airbourne 1,8-cineole levels. All the samples described here were supplied, collected and stored in line with best scientific practice. They were then subjected to analysis of 1,8-cineole levels using gas chromatography/mass spectrometry (GC/MS).

SOLVING THE CASE

The study consisted of a number of stages. In early investigations, wines were made from batches of grapes harvested at set distances from *Eucalyptus* trees in single vineyards in Western Australia and Victoria. The results in Figure 1 clearly show that the greatest amount of 1,8-cineole was found in wines made from grapes taken from rows closest to the *Eucalyptus* trees. In Victoria, grapes harvested within 50 metres of *Eucalyptus* trees produced wine with a 1,8-cineole concentration of 15.5µg/L, and grapes harvested from rows further away produced a wine with an extremely low 1,8-cineole level of just 0.1µg/L (Figure 1).

In another investigation, wines from consecutive vintages were analysed from the Coonawarra region in South Australia. The vineyard concerned was in close vicinity to well-established *Eucalyptus* trees. In this case, the wines produced from this vineyard contained relatively high amounts of 1,8-cineole, at 47µg/L (2006 vintage) and 81.5µg/L (2007 vintage), and were considered by the winemaker to display an obvious 'eucalypt' character. They were not sold commercially and may have been blended with other wine, which is a common practice among winemakers to adjust and refine wine sensory attributes.

These investigations supported the theory that the presence of 1,8-cineole was likely to be related to *Eucalyptus* trees. Additional vineyard studies were still needed, however, to work out how the compound was transferred from the trees to the vineyard and, ultimately, into wine.

To find out, the AWRI turned its attention to the relationship between grape composition and proximity to *Eucalyptus* trees; this included the analysis of grape berries, grape stems and grape leaves. A vineyard with *Eucalyptus* trees close to the vines, that had a history of producing wines with 1,8-cineole concentrations well above sensory threshold levels, was chosen to study.

Analyses showed that grape skins contained much higher concentrations of 1,8-cineole than grape pulp (Figure 2) and that grape stems and grape leaves had even higher levels. To confirm that airborne transmission was responsible for the transfer of 1,8-cineole – from *Eucalyptus* trees to the vines located close by – passive traps to capture the volatile aroma compound through adsorption onto polyethylene sheets were placed in the canopy at different locations at set distances from the *Eucalyptus* trees.

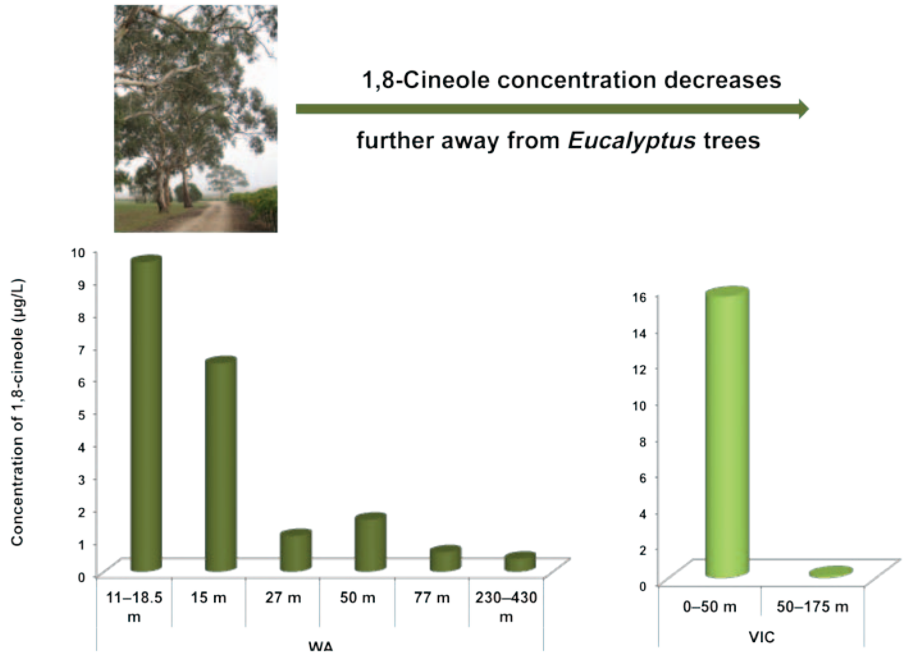

Figure 1. Concentration of 1,8-cineole (µg/L) in wines made from grapes collected at set distances from the *Eucalyptus* trees grown in Western Australia and Victoria.

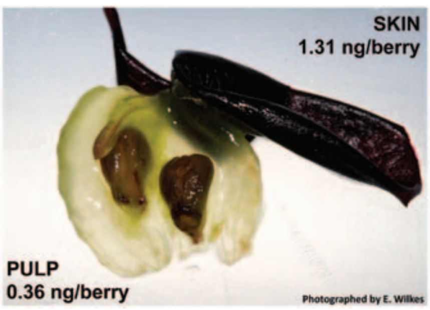

Figure 2. Distribution of 1,8-cineole found within the grape berry.

Again, the results confirmed previous findings: the closer the traps (and vines) were to *Eucalyptus* trees, the higher the concentration of 1,8-cineole.

Leaves from *Eucalyptus* trees themselves also appeared to play a role. When the researchers collected bunches of grapes for the study, they often found *Eucalyptus* leaves lodged in the canopy and within the grape bunches in vines closer to *Eucalyptus* trees. The next step, therefore, was to quantify the effect on 1,8-cineole concentration if *Eucalyptus* leaves found their way into ferments, in the form of MOG in the harvest bin.

Five hundred and fifty kilograms of Shiraz fruit were picked by hand from the rows close to *Eucalyptus* trees, taking special care to avoid MOG. The fruit was randomised and split into separate lots (50kg) for different treatments: one lot was pressed immediately (rosé style); a second lot contained crushed berries only with all grape stems and leaves thoroughly removed (no MOG); a third included grape leaves (500g) and stems (1.3kg) and the final batch included four *Eucalyptus* leaves and a small piece of bark (total weight 3.5g). 1,8-Cineole concentrations were determined daily throughout fermentation.

Again, the results were striking. While the inclusion of grape leaves and stems increased the concentration of 1,8-cineole, adding less than a handful of *Eucalyptus* leaves had the most dramatic effect of all: it increased concentrations of the compound from under 2µg/L (for the control, i.e., no MOG) to above 30µg/L (Figure 3, see page 26).

Given the high numbers of *Eucalyptus* trees in the Australian landscape and the fact that large amounts of *Eucalyptus* leaves can be found naturally in grape bunches – we found 33 *Eucalyptus* leaves in just one 550kg lot of hand-picked fruit – the impact of *Eucalyptus* leaves on wine character cannot be underestimated.

EUCALYPTUS BY DESIGN

The results were clear: the presence of *Eucalyptus* leaves – and to a lesser extent grapevine leaves and stems – were key drivers behind concentrations of 1,8-cineole in wine.

While there were apparent differences between vintages, the proximity of *Eucalyptus* trees had an obvious effect. The impact of MOG – and Eucalyptus leaves in particular – was also very clear (Figure 3).

While not all *Eucalyptus* species have high levels of 1,8-cineole in their leaves, many of the common trees in winegrowing regions, such as *Eucalyptus leucoxylon* (Yellow Gum), have great potential to affect vineyards. In hindsight, it should not be too surprising that *Eucalyptus* leaves or bark falling from trees can be blown some distance by the wind to lodge in grapevine

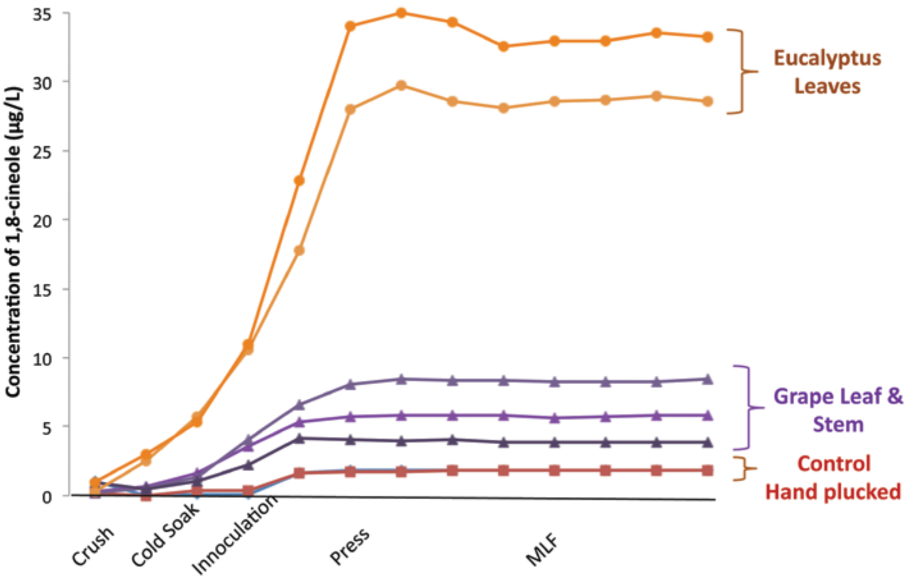

Figure 3. Concentration of 1,8-cineole (µg/L) during fermentation and the finished wine from the MOG experiments.

canopies, and from there be picked with the harvest to affect the wine. This source had not been previously considered, however, with popular thinking that airborne transfer of the eucalypt essential oil volatiles was probably the main avenue. Even though the leaves are dried and brown within vine canopies, they clearly can influence the character of a wine, and are of greater importance to ultimate 1,8-cineole levels in a wine than simple aerial transfer of the volatiles from the trees to the berry skins.

For winemakers, this presents a range of management options in terms of minimising or maximising 'eucalypt' characters. Wine producers may choose to ferment grapes from vines growing near *Eucalyptus* trees separately and use this wine as a blending option; they can hand pick those rows closest to trees; or they can ensure that minimal MOG is included in machine harvest bins of grapes. Sorting tables, whether manual or automated, would also be effective but obviously more costly. Adjusting machine harvester settings so that less non-grape material is picked, especially in rows closest to trees, would be another straightforward strategy. By paying closer attention to the volume of grape leaves, stems and *Eucalyptus* leaves or bark in their ferments, winemakers can exert greater control over the wines they are seeking to create.

This AWRI research also revealed another surprise. It was observed that the 50kg ferments containing additions of grape leaves (but not *Eucalyptus* leaves) and grape stems had significantly elevated concentrations of another key aroma compound, rotundone, and produced wines with a strong 'peppery' aroma (Figure 4). These results require further validation on a commercial scale, but could provide a new way to manipulate rotundone concentrations and 'peppery' aromas in wine which has not been obvious to winemakers before. The discovery could be particularly important for red wine made with whole bunch pressing or for ferments containing some grape

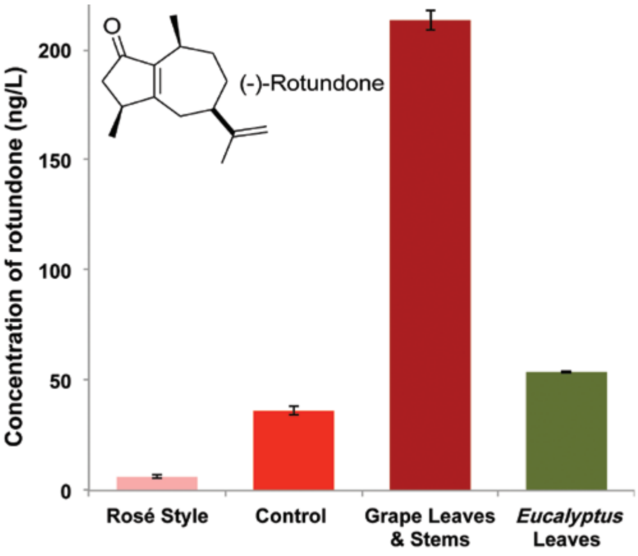

Figure 4. Mean concentration of rotundone (ng/L) in the finished wines from the MOG experiment. Error bars represent the standard deviation from the mean for the replicated ferment treatments.

leaves and stems, and is another example that grape processing and winemaking conditions have rather profound effects on wine flavour and expression of 'terroir'.

Overall, the results described here give winemakers practical ways to control 1,8-cineole concentrations throughout vineyard and winery operations. The closeness of grapevines to *Eucalyptus* trees has a conclusive effect on 1,8-cineole concentrations in wine, and the presence of MOG can significantly influence 1,8-cineole levels. Both factors have a major impact on sensory characteristics. Enhancing or reducing 'eucalypt' characters is no longer a case of pure chance or serendipity, and winemakers are in a much stronger position to take greater control of 1,8-cineole and adjust eucalyptus character to create wines that express their 'terroir' with market appeal.

ACKNOWLEDGEMENTS

The authors wish to acknowledge numerous Australian wine companies for the generous donations of grape and wine samples, and the contributions of numerous colleagues in particular Drs Mark Sefton and David Jeffery for their contribution to this work and assistance in the preparation of this article. This work was supported by Australia's grapegrowers and winemakers through their investment body, the Grape and Wine Research and Development Corporation, with matching funds from the Australian Government. The AWRI is a member of the Wine Innovation Cluster. The authors acknowledge the editorial assistance of Sharon Mascall-Dare and Rae Blair.

For further experimental details on this work, read:

Capone, D.L.; Jeffery, D.W. and Sefton, M.A. (2012) Vineyard and fermentation studies to elucidate the origin of 1,8-cineole in Australian red wine. J. Agric. Food Chem. 60:2281-2287.

Capone,D.L.; van Leeuwen, K.; Taylor, D.K.; Jeffery, D.W.; Pardon, K.H.; Elsey, G.M. and Sefton, M.A. (2011) Evolution and occurrence of 1,8-cineole (Eucalyptol) in Australian Wine. J. Agric. Food Chem. 59:953-959.

Osidacz, P.; Geue, J.; Bramley, B.; Siebert, T.E.; Capone, D. and Francis, I.L. (2010) Exploring the influence of pepper, eucalyptus and smoky flavour compounds on consumer preferences of red wines. AWRI Tech. Rev. 189:8-11.

Herve, E.; Price, S. and Burns, G. (2003) In Proceedings VIIème Symposium International d'Œnologie, Actualités Œnologiques, Bordeaux, Lonvaud, A.; De Revel, G. and Darriet, P. (Eds) Tec & Doc; Lavoisier: Paris, France; 598-600.

Farina, L.; Boido, E.; Carrau, F.; Versini, G. and Dellacassa, E. (2005) Terpene compounds as possible precursors of 1,8-Cineole in red grapes and wines. J. Agric. Food Chem. 53:1633-1636. WVJ