The implications of smoke taint and management practices

AWRI

By Con Simos[1]

Introduction

The early 2007 fires in eastern Victoria resulted in a loss of approximately 1.4 million hectares of natural habitat. Considerable damage was also inflicted on some agricultural crops. However, for the grape industry the significant loss is incurred through permeation of smoke taint into fruit and into the resultant wine, suffered by wine-producing regions in smoke-affected areas.

Before and during the 2007 vintage, the AWRI worked closely with many key stakeholders to identify the mechanism of smoke taint and how it influences the vine and the impact on fruit development. Our objective was to identify winemaking management techniques that will lessen the impact of smoke and bush fire taint on final wine quality.

Our knowledge on this subject of smoke taint has increased substantially, although most of our findings at this stage have raised more questions than answers. This article lists valuable information gathered at the AWRI in 2003 and some of the more recent developments.

South Eastern Australia, the Mediterranean and Southern California have the reputation of being the three most fire prone areas in the world (CSIRO 2007). In the last year, significant fire events have occurred in each of these three regions.

The 2008 vintage is likely to be dry with below average rainfall forecast especially in the Murray-Darling Basin. Rainfall between July and September this year over much of the Basin has continued to be below average or much below average. This is also against a backdrop of multi-year rainfall deficits and record high temperatures (Murray-Darling Basin Commission 2007).

These conditions might also be conducive to fire events being experienced somewhere in Australian grapegrowing regions next vintage. Climate change is likely to have a significant long-term impact on our agricultural industries. The chief executive of the Climate Change Institute, J. Conner, is quoted as saying, “if we don’t cut greenhouse pollution significantly we will see an almost tripling of fire weather conditions by 2050.” (Peddie 2007).

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Analysis for ‘smoke taint’

The AWRI, through its Analytical Service, offers an analytical technique which measures guaiacol and 4-methylguaiacol, for grapes, juice and wine. This analysis was recently adapted to measure leaves and canes, enabling us to obtain a better understanding of localised smoke taint sources within the vine.

Guaiacol and 4-methylguaiacol are volatile phenols and already exist in wine as a function of oak maturation. Guaiacol is the principal component resulting from oak barrel toasting where concentrations of 20µg/L are considered a highly positive attribute (with oak lactones, vanilla and hydroxymethylfurfural). It has also been discovered, through a study of Merlot juice, that guaiacol can also be formed naturally, at levels of up to 20µg/L, through hydrolysis of fruit derived precursors (Sefton 1998).

The compounds guaiacol and 4-methylguaiacol are considered as two important markers of smoke taint and correlate strongly with mean sensory taint scores; descriptors include ‘smoky’, ‘burnt’ and ‘ash’ characters. Non-volatile, larger molecular weight compounds contribute characters on the palate normally described as ‘cigarette’, ‘ash tray’, ‘acrid’ with a hard metallic and a persistent unpleasant finish. The presence of these smoke compounds is likely to have a negative effect in terms of final wine quality and ultimately commercial acceptance. There could also be hundreds of other unidentified compounds which could contribute to the total level of smoke taint. Work to identify other compounds has not been undertaken due to a limitation of research resources.

The perception of smoke taint is strongly related to the structure/body of the smoke affected juice or wine. In white juice sparkling base, winemakers could observe smoky characters as low as 6-10µg/L guaiacol; in medium bodied red wines thresholds are 15-25µg/L. In fuller bodied Shiraz styles, the threshold could range from 30-40µ/L.

Guaiacol is stable and its sensory impact on a wine becomes more prominent as the wine ages. This is a function of the loss of primary fruit characters, which tend to mask smoke characters. It is, therefore, not advisable to re-blend smoke affected wines to a level just below sensory threshold before ageing and bottling.

The AWRI does not advocate and has never advocated the setting of limits of smoke compounds as a harvest grading or a rejection tool.

Recently, the AWRI fielded many enquiries from industry concerning what constitutes a ‘safe’ level of ‘smoke compounds’ in grapes. A number of factors come into play which makes prediction of the level of smoke taint in the resultant wine very difficult.

Following a fire event, there is considerable variation in smoke taint among vines within the same vineyard. This is due to the type of fire, intensity, and duration of smoke cover, wind vectors, proximity to fire, land topography, etc.

Vines would also be subject to physiological differences, canopy development, and health status. Fire events occur in the drier, hotter periods, so water stress in vines would further exacerbate any of the above influences.

How the grapes are treated at harvest and post-harvesting also has a great influence. The AWRI has spent considerable time on developing harvesting and winemaking practices which can mitigate some of the taint influences. Some of the findings are included in this article.

The combination of all of these factors creates a dynamic matrix capable of delivering huge differences.

To illustrate variation in the vineyard, the AWRI carried out a trial in conjunction with a winery. This winery sourced fruit from a vineyard in South Australia which experienced a fire event in early December 2006. The duration of this fire event was 24 hours, with the fire encircling the complete vineyard; the heat was severe enough to melt some of the irrigation hoses. Table 1 details the results of analysis of leaves and red grapes randomly selected from this vineyard.

In this study, four vines were selected randomly from approximately 1800 vines, the sampling was not intended to be statistically relevant, but rather to identify the presence of any likely trends; anecdotal evidence indicated wide discrepancies between vineyard sampling and post-harvest results. The fruit was harvested in March 2007 and samples of leaves were also taken. These were stored frozen until such time as the leaves could be analysed.

The most important conclusion from this trial is the presence of guaiacol in the leaves at elevated levels relative to the guaiacol concentration found in the fruit. Clearly, more work will have to be done to determine the relationship between guaiacol concentration in the leaves and the presence of smoke taint in the resultant fruit. Leaves sampled from 'non-smoke' tainted vineyards contained no guaiacol, (above a reporting limit of 0.1µg/kg).

The fruit from the above four vines was then combined and fermented in a small-scale fermentation.

Figure 1 shows the evolution of guaiacol in the red wine fermentation; at the onset of fermentation the concentration of guaiacol was 1µg/L. By the third day, most of the guaiacol had been expressed from the skins and thereafter the level of guaiacol remained relatively constant, or increased slightly. The evolution of guaiacol in this instance was consistent with similar observations carried out in large-scale winery fermentations. This wine was considered to be 'moderately' tainted, although still unacceptable for commercial wine production.

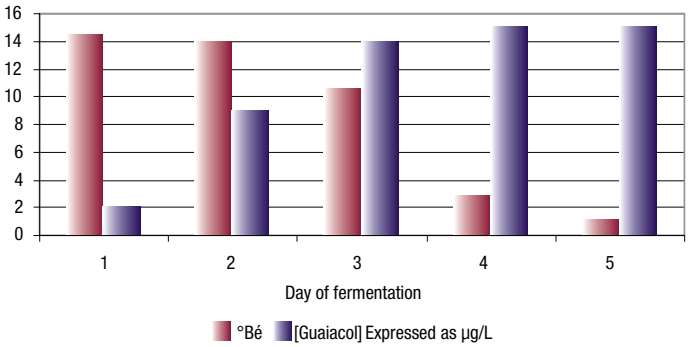

Figure 1. Evolution of Guaiacol in a smoke tainted red ferment.

A possible hypothesis to explain the mode of entry of smoke taint compounds into the vine would be as follows: During a bush fire event, airborne solid and liquid smoke particulates are mixed with air and dispersed throughout the environment as a function of wind vectors, land topography and temperature gradients. Where a fire event occurs in close proximity to a vineyard, the smoke particles would be intercepted and become entrapped by the large leaf surface area of a vine; smoke particles could enter the leaves via the protective waxy cuticle layer or stomata (Beattie 2006). Other parts of the vine, canes, growing shoot tips and fruit are also directly exposed, although it is the leaves with the largest surface area that could act as a significant capture mechanism and reservoir of smoke particulate matter. Once the vine has attained a mature full canopy, sugars are then channelled via the phloem into the developing fruit. Post veraison, guaiacol and other compounds, could be translocated through the vine, in a molecular form or bound to other substances, possibly sugars. We already know that there is a cumulative effect, and guaiacol (smoke taint) levels will continue to increase in the fruit well after the actual fire event.

If the leaves do act as a reservoir for channelling smoke taint into the fruit, then this would also have implications for prescribed burning-off periods.

Table 1. Results of analysis of guaiacol and selected harvest parameters of leaves and grapes sampled randomly from a smoke tainted red vineyard.

Vine	Total harvested fruit weight per vine (kg)	Ripeness at sampling °Brix	Leaves (Guaiacol µg/kg)	Grapes (Guaiacol µg/kg)
1	2.84	23.5	64	0
2	1.13	22.4	45	1
3	4.73	26.6	49	1
4	1.41	21.7	71	2

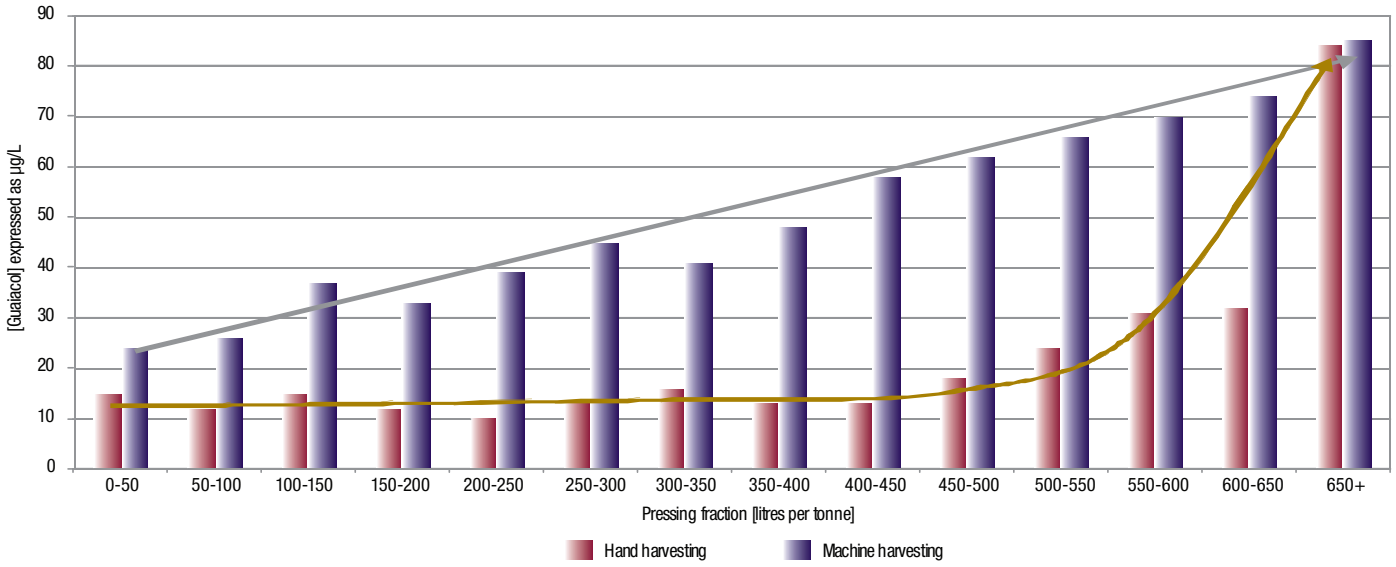

Figure 2. Comparison of hand harvesting and machine harvesting on the guaiacol levels in a white juice.

Extensive testing carried out by the AWRI in 2003 (Godden *et al*. 2003) found that leaf removal around the fruit and water washing in the vineyard was only effective when utilising high water volumes and at high water pressure. Once smoke has permeated a canopy it would pose a logistical problem to remove the leaves effectively; furthermore this would also have to be done as quickly as possible after a fire event.

At this stage, there is no conclusive evidence to suggest that carry over from a smoke affected vintage will influence the developing fruit in the following year; trials are currently being undertaken.

The other area of current research is to identify the mechanism of 'bound guaiacol' fractions (and other compounds) that might be released during fermentation, possibly by the enzymatic action of yeast. At this stage this action could be related to ß-glucosidase activity, other enzymes may also be responsible.

Figure 2 shows results from trials involving white grapes, which support the view that much of the guaiacol is resident within the inner layers of the skin and not the pulp. These results indicate that to minimise release of guaiacol the winemaker's objective is to minimise deliberate breaking or rupturing of the skin for as long as possible during processing. Careful hand-harvesting followed by bunch pressing could minimise most of the smoke taint characters for the first 400L/t. Chilling the fruit and processing cold would also be beneficial (see Figure 3).

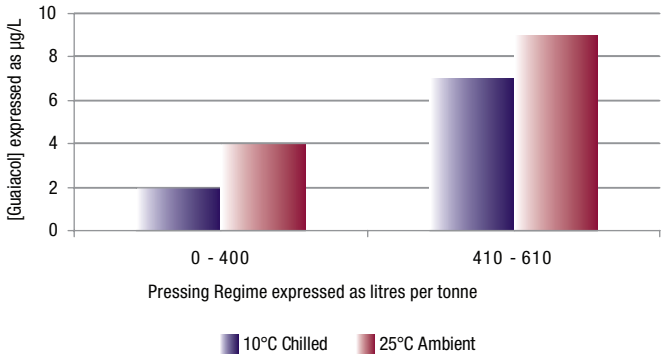

Figure 3. Effect of temperature on guaiacol extraction in whole bunch pressed white grapes.

A series of pressings cuts should then be made, with each fraction being fined and treated separately. Carbon is the most effective fining agent although its action is not selective. If carbon is to be used; add bentonite at a rate of <0.5g/L as this will assist in flocculation, and follow through with earth filtration. It is not advisable to ferment in the presence of carbon. Fermentation of filtered juices will also have an implication on fermentation rate. To avoid sluggish or sticking fermentations, blend a portion of juice solids from a non-smoke taint juice if possible.

Recommendations

It is unlikely that easy solutions will be found in effectively managing smoke taint once a decision has been made to harvest. Rather, a series of processes will have to be employed, some of which will add significantly to the cost of production.

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White juice production	Red wine production
Hand harvest – no leaves	Hand harvest – no leaves
Chill fruit overnight before bunch pressing	The longer the maceration period on skins the greater the level of perceived smoke taint
Pressings cut 400L/t	Yeast and tannin combinations could offset some of the smoke taint characters
Perform carbon trials at the juice stage and fine as early as possible i.e. pre-fermentation	Reverse osmosis has proven to be an effective technique at reducing guaiacol and 4-methylguaiacol
	Judicious blending

Acknowledgements

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Sunraysia community in safe hands thanks to Lindemans equipment donation

The Lindemans Karadoc winery has donated important lifesaving equipment to the Country Fire Authority at Mildura.

The confined space rescue equipment is valued at $20,000 and was bought for use at the Lindemans Karadoc site.

However, the company decided it would be of greater value if it were available to the entire Sunraysia community.

The CFA says the Emergency Response Team equipment could be critical in saving lives during rescues of people in confined spaces and trenches.

Spokesman Ken Diamond said the wine and grain industry meant people in the Mildura region were often working around tanks, vats and silos.

The equipment will be kept at the CFA Mildura headquarters. ■

PRODUCTS AND SERVICES

Davey Water Products 'Fire 5' series pump.

Bushfire protection options for peak summer season

Protecting a property in a firestorm situation is increasingly a matter of looking after the protection of your building and other assets, including vineyards.

Most firefighting authorities like Victoria's Country Fire Authority recommend the preparation of a personal fire plan including the appropriate materials such as a water pump, especially if there is a decision to stay with the property under bushfire conditions.

Some property owners will have a water source they are able to tap in the form of the contents of rainwater tanks, watercourses, dams or similar reserves.

In this instance a Davey Firefighter® engine powered pump with an inlet and outlet hose kit, representing a relatively inexpensive investment, will usually afford the means to extinguish embers, spot fires or even burning vegetation, particularly in advance of, or after a fire front has passed.

The next step-up in bushfire protection is to install a permanent custom-designed reticulated sprinkler system which will provide a deluge spray of water that is able to cover and protect all points of a building, including walls, windows, decks, roof, sky lights, under floor areas, gas bottles and even the rainwater tanks since these are likely to be constructed of plastic and are at risk of damage or loss of their contents.

Blaze Control Sprinkler Bushfire Systems located in Lilydale, Victoria, has installed building protection systems throughout southern Australia including in a winery building and in many homes in remote or forested surroundings.

A Blaze Control system begins with a Davey Firefighter engine powered pump typically drawing on a rainwater tank storage system. The pump can operate with a manual rope start, an electric start or a remotely operated pump which can be activated electronically once a fire emergency is determined.

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