Technical notes

Smoke taint: analysis and interpretation

Background

Over the past 15 years, bushfires and controlled burns have sometimes exposed vineyards and grapes across the world to smoke. Such exposure can result in wines with undesirable sensory characters described as 'smoky', 'burnt', 'ash', 'smoky bacon', 'medicinal' and 'ashtray'. Wines which develop these sensory characteristics after vineyard exposure to smoke are generally referred to as 'smoke tainted'. Research has shown that the compounds in smoke primarily responsible for the development of smoke-tainted wines are free volatile phenols (Parker et al. 2012), which are some of the products generated during the combustion of plants such as trees and grasses. Research has also shown that these volatile phenols can undergo biotransformation once they enter grapevines to give glycoside, or 'bound', forms of the phenols (Hayasaka et al. 2010a,b). During fermentation some of the glycosides convert to the free volatile phenol compounds. Hence, the non-volatile glycosides can be considered precursors to the volatile phenols, which are responsible for the aromas and flavours of smoke taint.

Both the free volatile phenols and their glycoside forms are important in the development of smoke taint and can be used as markers for smoke exposure (Hayasaka et al. 2011). Consequently, the AWRI recommends that smoke-exposed grapes be tested for both groups of compounds to help assess the risk of producing a smoke-tainted wine. When a vineyard has been exposed to smoke, knowing the levels of key volatile phenol and glycoside compounds in grapes can assist with assessing the risk of smoke taint and making harvesting decisions.

As indicated above, a portion of the smoke taint glycosides can release their volatile phenols during fermentation to cause a smoke-tainted wine. In addition to testing grapes, a small-scale ferment of potentially affected grapes can be carried out followed by sensory assessment and chemical analysis. This may allow winemakers to further gauge the potential risk of producing a smoke-tainted wine from smoke-exposed grapes.

Smoke Taint Panel analysis

AWRI Commercial Services offers a smoke taint analysis (listed as 'Smoke Taint Panel' in the analysis price list) for grapes, juice and wine, which includes analyses of both the free volatile phenol compounds and the phenolic glycoside compounds. The compounds tested as part of the Smoke Taint Panel analysis are listed in Table 1.

Given the volatile phenol compounds can accumulate in smoke-affected grapes in their glycoside forms, it is possible for volatile phenols to be present in relatively low concentrations while the glycosides are present in relatively high concentrations (Parker et al. 2013). Therefore, if smoke-exposed grapes happened to contain a high concentration of phenolic glycosides but a low concentration of volatile phenols, then testing only for volatile phenols would result in an underestimation of the risk of producing a smoke-tainted wine.

The most effective time to test smoke-exposed grapes is as close to the expected harvest date as possible, although enough time should be left to allow for transport to the laboratory and for the analysis to be conducted, before the decision whether to harvest needs to be made.

Note that in the case of wines submitted for the Smoke Taint Panel analysis, oak contact can make interpretation of the volatile phenol results difficult. This is because volatile phenol compounds can be released from oak, especially heavily toasted oak, during fermentation and wine ageing (Spillman et al. 2004).

Background levels survey

Once the Smoke Taint Panel analysis had been developed, it became apparent that non-smoke-exposed grapes naturally contain low levels of the various compounds targeted by the analysis. This revealed the possibility that 'false positive' interpretations could be made. That is, low-level Smoke Taint Panel analysis results might suggest that grapes have been exposed to smoke when in fact the results might be within the natural 'background' range for non-smoke-exposed fruit. In addition, it was observed that the levels of the various compounds varied somewhat from variety to variety. Therefore, it was necessary to conduct a survey of the typical background concentrations of the marker compounds included in the Smoke Taint Panel analysis for the major grape varieties.

Table 1. The smoke taint marker compounds targeted as part of AWRI Commercial Services' Smoke Taint Panel analysis

Volatile phenols	Phenolic glycosides
Guaiacol	Guaiacol rutinoside
4-Methylguaiacol	Methylguaiacol rutinoside
Syringol	Syringol gentiobioside
4-Methylsyringol	Methylsyringol gentiobioside
o-Cresol	Cresol rutinoside
m-Cresol	Phenol rutinoside
p-Cresol	

During 2010 and 2011, volatile phenols and phenolic glycosides were measured in non-smoke-exposed fruit collected approximately two weeks before the commercial harvest date for the varieties Cabernet Sauvignon, Shiraz, Pinot Noir, Chardonnay and Riesling. The grape samples collected during the survey were also fermented to wine so that the background concentrations of the marker compounds could be determined for both grapes and wine. The analytical results were subjected to statistical analysis to determine upper limits for the background levels of the various marker compounds included in the Smoke Taint Panel analysis. If samples subjected to the Smoke Taint Panel analysis returned results that were higher than these upper limits, then they were deemed likely to have been exposed to smoke (Parker et al. 2013).

During 2016 and 2017, the 'background survey database' was expanded to include seven more varieties. The varieties currently included in the database are listed in Table 2. The database now includes data obtained from more than 500 grape samples acquired from 23 regions across Australia.

Interpretation of Smoke Taint Panel results

When a grapegrower or winemaker receives results of the Smoke Taint Panel analysis from AWRI Commercial Services, they are advised to contact the AWRI helpdesk for interpretation. Interpretation involves comparing the results with those from the 'background survey database' for the particular variety analysed. To assist with understanding the results, a 'traffic light' colour-coded system was initially developed. For a volatile phenol result, for example, the result was designated as being either 'green', 'amber' or 'red', depending on how far the result lay from the mean of the background survey data for the variety. After expansion of the database during 2016 and 2017, the 'traffic light' interpretation system was revised as part of the AWRI's continuous improvement process. As a result, a graphical system of interpretation was introduced in 2018.

Table 2. Varieties included in the AWRI's smoke taint background survey database

White varieties	Red varieties
Chardonnay	Cabernet Sauvignon
Pinot Gris/Grigio	Grenache
Riesling	Mataro/Mourvèdre
Sauvignon Blanc	Merlot
Semillon	Pinot Noir
	Sangiovese
	Shiraz

Graphical presentation of Smoke Taint Panel analysis results

Apart from discussing the Smoke Taint Panel analysis results with the grapegrower or winemaker, helpdesk staff may also provide two graphs, one with the volatile phenol results and one with the glycoside results. These graphs include data from the 'background survey database' with which the sample results can be compared. An example of how the result are presented is provided in Figure 1.

Although the y-axis values are not shown in Figure 1, the graphs show how the Shiraz sample results (represented by the open circles) can easily be compared to the background survey results (grey bars) for Shiraz grapes. The grey bars in Figure 1 represent the natural

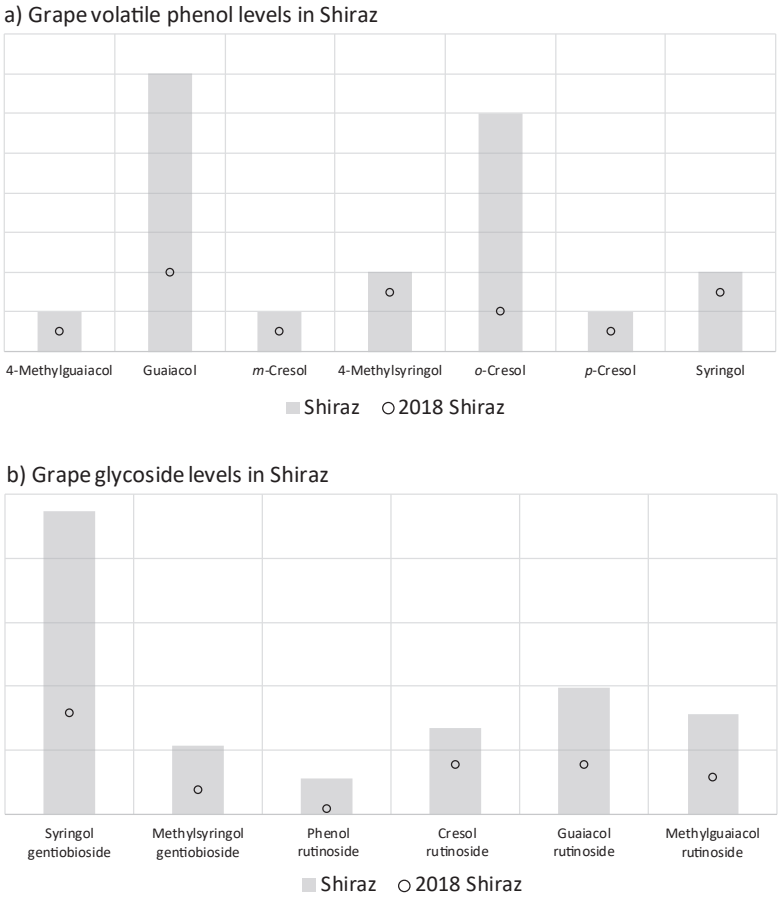

Figure 1. Graphs of a) volatile phenols and b) glycoside compounds measured in a sample of 2018 vintage Shiraz grapes possibly exposed to smoke (open circles) compared to the background levels for non-smoke exposed Shiraz (grey bars) obtained during the 'background levels survey'.

background levels found in Australian Shiraz grapes up to (and including) the 99th percentile for each analyte measured as part of the Smoke Taint Panel. That is, 99% of the data collected for non-smoke-exposed Shiraz gapes fall within the grey bars. Given both the volatile phenol and glycoside results for the 2018 Shiraz sample in Figure 1 fall within the grey bars (i.e. within the range of values typically observed for non-smoke-exposed Shiraz grapes according to the background survey), the conclusion is that there is no evidence the 2018 Shiraz grapes have been exposed to smoke.

It should be noted that if the Smoke Taint Panel results for a grape sample are slightly higher than the 99th percentiles for the background survey data (i.e. the results lie above the grey bars), this is evidence of smoke exposure only. Whether or not the wine resulting from processing the fruit will be smoke tainted cannot be drawn from this data alone. For example, consider Figure 2, which shows the wine glycoside results compared to the background data for a 2018 vintage Cabernet Sauvignon wine. The results for syringol gentiobioside and methylsyringol gentiobioside lie just above the range of values observed for Cabernet Sauvignon wines analysed in the background survey. This does not automatically mean that the wine will be affected by smoke taint, as the results for the other four compounds lie within the grey bars (i.e. these results are within the range observed for non-smoke-exposed Cabernet Sauvignon wines).

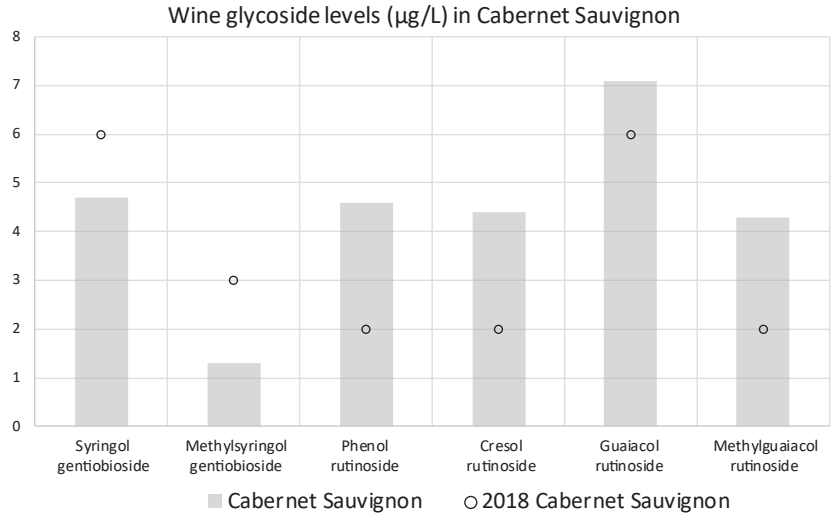

Figure 2. The levels of glycosides in a 2018 Cabernet Sauvignon wine for which the grapes may have been exposed to smoke (open circles), showing levels of syringol gentiobioside and methylsyringol gentiobioside just above the background levels for Cabernet Sauvignon (grey bars).

Inspection of Figure 3, which shows not only the results for the 2018 Cabernet Sauvignon wine, but also results for a smoke-tainted 2007 Cabernet Sauvignon wine, brings the results for the 2018 wine into perspective.

Even though the results for two of the glycosides in the 2018 wine are just above the 99th percentile (i.e. just above the top of the grey bars), the results are very low relative to the 2007 smoke-tainted wine. Given the syringol gentiobioside and methylsyringol gentiobioside results for the 2018 wine are above the background survey data 99th percentiles for these compounds, it is possible the grapes from which this wine was made were exposed to smoke. However, the results for the other four glycosides are within the grey bars (three of them in close proximity to the median), so the conclusion is that the 2018 Cabernet Sauvignon wine would be unlikely to exhibit smoke taint characters.

If all AWRI Smoke Taint Panel results for a grape sample are above the 99th percentiles for all the compounds targeted, then it is highly likely that the grapes were exposed to smoke. However, if the results are only just above the 99th percentiles, wine made from the grapes may not necessarily be affected by smoke taint. The risk of producing a smoke-tainted wine increases with results increasing in distance above the 99th percentile levels (i.e. risk increases with increasing distance above the grey bars). In summary, while low (within

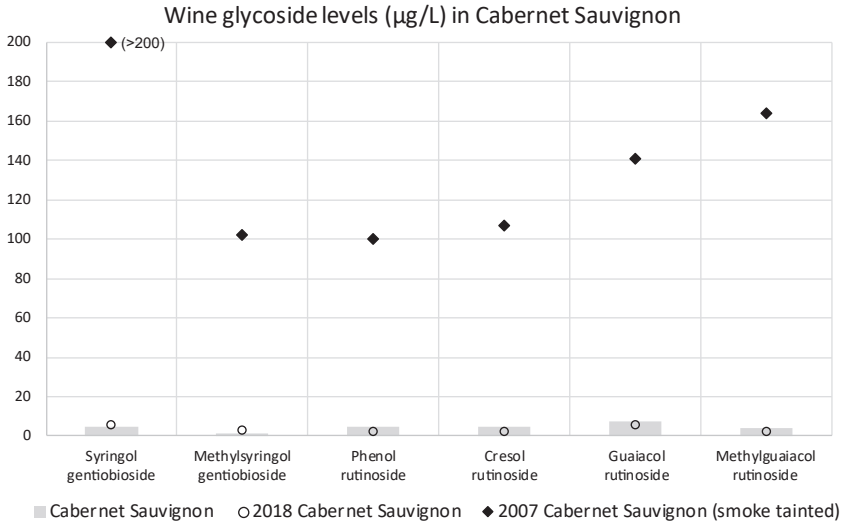

Figure 3. The levels of glycosides for the same Cabernet Sauvignon wine (open circles) shown in Figure 2 and the glycoside levels in a smoke tainted 2007 Cabernet Sauvignon wine (solid diamonds) compared to the background levels (i.e. no smoke exposure) for Cabernet Sauvignon (grey bars).

the grey bars) and high (well above the grey bars) levels of volatile phenols and phenolic glycosides are relatively easy to interpret (i.e. not smoke affected and most likely smoke affected, respectively), it is more difficult to interpret the effect 'intermediate' levels of these compounds will have on the sensory profile of a finished wine. The AWRI is currently involved in a collaborative project to determine the levels of volatile phenols plus phenolic glycosides required to induce the perception of smoke taint in wine.

References

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