

Smoke Taint Markers in Grapes and Wines

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Abstract

Smoke compounds absorbed by vines can cause an objectionable character in finished wines known as "smoke taint". The California wildfires of 2008, comprising over 2000 individual fires at their peak, exposed vines to smoke in various viticultural areas. Work in Australia identified two volatile phenols, guaiacol and 4-methylguaiacol, as useful markers for smoke taint. Data obtained from California's harvest 2008 provided new information and confirmed many of the observations reported elsewhere. Levels of guaiacol in grapes not exposed to smoke seldom exceeded 0.3 µg/kg. Samples from areas exposed to heavy smoke were found as high as 55 µg/kg. Levels in juice obtained from freshly pressed smoke-exposed berries were lower than levels in ground whole berries, confirming a higher concentration of smoke compounds in skins. Juice contact with skins further increased measured smoke markers. During the alcoholic fermentation of juices, guaiacol concentrations increased and were typically three times higher at the end of fermentation. With red wines, final levels were five to ten times higher than originally measured in corresponding grapes. These results supported that significant amounts of smoke taint compounds may be liberated from non-volatile precursors during the early stages of winemaking. The analysis of free markers in whole berries, however, confirmed to be an effective tool to predict the risk of smoke taint in wines.

The California Wildfires of Summer 2008

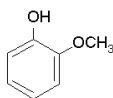
During the weekend of June 21-22, a dry low-pressure system crossed through California producing dry lightning and igniting The California Wildfires of Summer 2008, comprising over 2,000 individual fires at the series' height. The fires broke out after three years of below-normal rainfall dehydrated much of California's forests and woodlands, making them prone to wildfires (1,2).



Figure 1: NASA satellite view of California, June 23rd 2008. Active wildfires are highlighted in red.

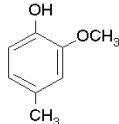
Guaiacol and 4-Methylguaiacol as Smoke Taint Markers

"Smoke Taint" in wines was first identified as a serious problem following the 2003 wildfires in Australia and British Columbia. Smoke compounds are absorbed by vines and grapes and end-up in finished wines where they can cause objectionable odors described as "burnt", "smoked fish", "salami", "ash" and "ashtray". Among the more than seventy compounds identified in smoke (3,4), guaiacol and 4-methylguaiacol (Figure 2) have been selected in Australia as the primary indicators of smoke taint. Both appear to be present in all smoke damaged wines and their concentrations usually correlate to the degree of taint present (6).



Guaiacol

Synonyms: 2-methoxyphenol, o-methoxyphenol, methylcatechol
Molecular Formula: C₇H₈O₂
Molecular Weight: 124.1
CAS Number: 90-05-1



4-Methylguaiacol

Synonyms: 2-methoxy-4-methylphenol, cresol
Molecular Formula: C₈H₁₀O₂
Molecular Weight: 138.2
CAS Number: 93-51-6

Figure 2: Structure and description of guaiacol and 4-methylguaiacol

Smoke Markers in Grapes

The analysis of guaiacol in whole processed berries has been routinely used by Australian wineries to assess the risk of smoke taint, with grapes reportedly downgraded for levels between 2 and 6 µg/kg (5, 6). Analysis at ETS was typically carried out on 200 berry samples, as collected for controls of maturity. Whole berries were finely ground in presence of an internal standard and extracted by Headspace/SPME. Analysis was performed by GC/MS. Calibration was built using berries not exposed to smoke, spiked with known amounts of guaiacol and 4-methylguaiacol. The method was shown to be linear to 20 µg/kg, with a detection limit of 0.1 µg/kg and excellent precision in the low µg/kg range (CVs <5 %). Guaiacol levels in grapes from areas not exposed to smoke were found between 0.1 and 0.3 µg/kg. By contrast, samples from areas directly impacted by wildfires showed several µg/kg, as high as 55 µg/kg (Figure 3). Results in the low µg/kg range, between 0.5 and 2 µg/kg, suggested grapes moderately impacted by smoke and were considered suspect, even as it was too early to know if corresponding wines would be tainted. Winemakers identifying such grapes could take action to mitigate the impact of the smoke at harvest, especially with white and rose wines (6).

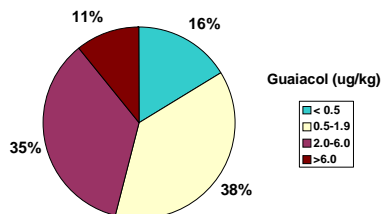


Figure 3: Occurrence of guaiacol in grape samples analyzed for smoke taint markers at ETS Laboratories during harvest 2008.

Levels in Berries and Juices

HS/SPME/GC/MS analysis of fresh juices showed that levels of guaiacol and 4-methylguaiacol were only a fraction of those found in corresponding whole berries (Figure 4). This confirmed an accumulation of smoke compounds in skins. Furthermore, levels in juice obtained from popped and soaked berries, after prolonged skin contact, largely exceeded those originally found in corresponding berries. This confirmed that significant migration of skin to juice and liberation from non-volatile precursors can take place during harvest and the early stages of winemaking (6, 8).

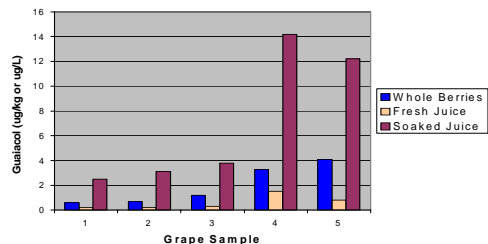


Figure 4: Occurrence of guaiacol in whole berries, freshly obtained juice, and juice obtained after 4 days of skin contact (soaked juice).

Levels Before and After Fermentation of Juice Without Skins

Levels of guaiacol and 4-methylguaiacol were monitored during the fermentation of grape juices without skins. A fast increase was observed during the first 10 to 20 days, then stabilized. Final levels in wines were approximately three times higher than originally present in berries (Figure 6). For white and rose winemaking, this highlights the importance of preventive actions to minimize the migration of smoke compounds from skin to juice during harvest and pressing of suspect grapes, so initial levels before fermentation are as low as possible.

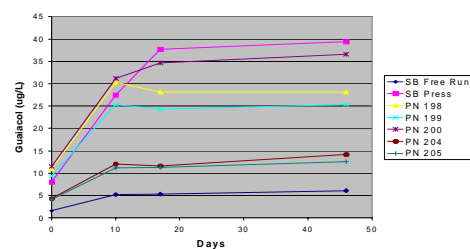


Figure 5: Evolution of guaiacol during the fermentation of grape juices without skins and post-fermentation.

Levels in Berries and Red Wine

Since red winemaking calls for the fermentation of juice in contact with skins and seeds, levels of smoke markers in whole berries should be a good indicator of final levels in corresponding wines. Indeed, guaiacol and 4-methylguaiacol measured in berry samples predicted the occurrence of tainted wines. As reported in Australia (6), levels in young wines (in µg/L) showed a dramatic increase, typically 5 to 10 times higher than those found in corresponding berries (in µg/kg) (Figure 5).

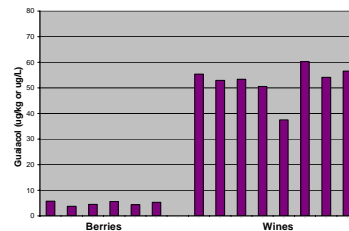


Figure 5: Levels of guaiacol measured in Pinot Noir whole berry samples, from a single estate exposed to smoke, and levels in wines analyzed after completion of fermentation.

Consequences and Applications:

Measuring the free fraction of guaiacol and 4-methylguaiacol in whole berry samples predicted the occurrence of smoke-tainted wines during the 2008 vintage in California. Testing grapes before harvest allowed winemakers to identify suspect grapes and take preventive actions, so the impact of smoke could be minimized whenever possible.

Analysis of wines assists sensory evaluations, and is the starting point when smoke taint removal treatments are considered.

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