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Smoke-derived taint in wine: the release of smoke-derived volatile phenols during fermentation of Merlot juice following grapevine exposure to smoke.

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• Due largely to a rash of wildfires resulting from climate-induced changes to the environment worldwide, many vineyards have had their fruit negatively impacted by exposure to smoke. This exposure has ultimately led to a characteristic "smoke taint" in the resultant wines, which has been described as "smoky", "dirty", "burnt" aromas with a lingering retro-nasal "ash" character on the palate. These authors, and others, have determined that a number of volatile phenols, specifically guaiacol, 4-methylguaiacol, 4-ethylguaiacol, 4-ethylphenol and eugenol are the main causative agents of the smoked character, although they admit there are probably other less obvious compounds that haven't been indentified. But the two most common, guaiacol and 4-methylguaiacol, represent useful marker compounds and, therefore, can be indicative of levels of smoke taint in grapes and wine.

• In previous studies (see summary # 124) the authors observed the intensity of smoke taint to increase during and after the fermentation of affected grapes. The release of volatile secondary metabolites (those appearing in very minute concentrations) from both grape and oak-derived flavor precursors has been previously demonstrated by way of enzyme- and acid-catalyzed hydrolysis. This could explain the increase of smoke taint during fermentation, as non-volatile precursors are hydrolyzed to volatile components. At the time of the study, the assessment of smoke taint relied strictly on sensory evaluation or analysis of guaiacol or 4-methylguaiacol. This study was undertaken to investigate: 1) the evolution of smoke-derived volatile phenols during fermentation, after exposure to smoke in the vineyard, 2) the release of these volatile phenols under acid- and enzyme-catalyzed reaction conditions, and 3) the implications of the results for analyzing smoke-affected grapes and juice.

• To conduct this study, tented Merlot grapevines in Western Australia were exposed to eight successive smoke applications, 30 seconds each, between veraison and harvest. Control vines were also held in tents without smoke for the same periods of time. Small-scale wines were made in replicates of three, using standard winemaking protocol. Each treatment was also tested for evolution of volatile phenols using both strong acid (pH1.0) hydrolysates and mild acid (pH 3.2 and 3.7) hydrolysates. Enzyme hydrolysates were prepared by treating juice with ß-glucosidase

• **Results**: The volatile phenols mentioned above were either not detected or detected at only trace levels in the free run juice derived from grapes in the smoke treatment. The concentrations of these compounds increased dramatically throughout fermentation, with the highest levels observed in the finished wines. Earlier Australian studies had suggested that guaiacol and 4-methylguaiacol were accumulated in the skins, rather than the pulp, of affected grapes. Those researchers were confident that extraction from the skins was the reason for the increase in concentrations during fermentation. However, these authors found that phenol concentrations continued to increase after the wines were pressed off the skins and throughout malolactic fermentation. This implied the presence of one or more precursor compounds, rather than further extraction. For instance, in the case of **guaiacol**, the most abundant of the compounds, they found the following concentrations:

	Smoked (µg/L)	Control (µg/L)
• free run juice	1	nd
• after 1 day maceration	68	tr
• after 3 days maceration	68	tr
• after 5 days maceration	203	tr
• after 7 days maceration	249	tr
• at pressing	249	1
• in finished wine	388	4

• The hydrolytic studies confirmed the release of smoke-derived volatile phenols in both acid- and enzyme-catalyzed reaction conditions, which supports the accumulation of these phenols in smoke-affected grapes as precursors. The hydrolysates of the strong acid and the enzyme both smelled intensely of "smoke" and "smoked meat" by informal sensory evaluation. In stark contrast, the mild acid hydrolysates exhibited "berry", "fruit" and "jammy" aromas, with volatile phenols present only at trace levels.

• At normal juice pH, most of the precursors discussed are relatively stable toward chemical hydrolysis, so significant quantities of guaiacol and 4-methylguaiacol would not be expected to form by hydrolysis alone in wine. However, micro-organisms with ß-glucosidase activity could form these compounds during fermentation. Because of that, the enzymatic release of smoke-derived volatile phenols provides a plausible explanation for the increase in guaiacol and 4-methylguaiacol during fermentation.

• If it's true that these volatile compounds do accumulate in grapes as odorless precursors following exposure to smoke, there may be no indication of taint at harvest, but the offending compounds could form during, and after, fermentation. For the determination of guaiacol and 4-methylguaiacol precursors in juice, the authors suggest that enzyme hydrolysis may be more appropriate for commercial samples, where less intense smoke exposure would likely give lower volatile phenol levels. As such, the potential under-estimation of smoke taint can be reduced.

• Conclusion: Since it is currently very difficult to assess the potential level of smoke taint in wine by a sensory evaluation of the grapes or even juice, these authors suggest that the best method of detection available now is an enzymatic hydrolysis of juice samples. As a proactive strategy, the production crew could then decide how best to direct their efforts.

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