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Smoke-derived taint in wine: effect of postharvest smoke exposure of grapes on the chemical composition and sensory characteristics of wine.

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• Many vineyards are planted in areas that can become victim to wildfires. Despite the international nature of this phenomenon, there has been little research done to relate the effect of smoke on plant physiology or the composition of grapes and/or wine quality. These Australian researchers decided to see if they could demonstrate a direct link between grape exposure to smoke and the development of "smoke taint" in grapes and resultant wines.

• Numerous volatile compounds, including phenol derivatives, carbonyls, organic acids and their esters, lactones, pyrazines, and furan and pyran derivatives, have been reported in smoke and smoke flavorings. Of these, "smoke aroma" has mainly been attributed to the phenol derivatives guaiacol (Gu)and 4-methylguaiacol (4MGu), which have been characterized as "smoky", "phenolish", "burnin g wood", "ash", "sharp", "sweet", and "smoking bacon". Since both these compounds are derived from lignin degradation during the toasting process of cooperage, they are routinely identified in wines matured in oak barrels. Their aroma thresholds in white wine have been reported as 95µg/L (Gu) and 65µg/L (4MGu). In red wines, their thresholds are reported as 75µg/L and 65µg/L, respectively. It's possible that these compounds could accumulate in grapes as a result of smoke exposure, and their presence in elevated concentrations could lead to apparent taint.

• Using Verdelho grapes harvested at about 24°Brix, the fruit was divided into two smoked parcels and two unsmoked parcels. For the smoked parcels, the authors placed whole bunches on wire racks and exposed them to straw smoke for one hour at ambient temperature. After exposure, the clusters were randomly mixed to reduce the inherent variation in smoke exposure. The parcels were then divided into two smoked lots and two unsmoked lots. These were processed to produce four experimental wines: 1) wine made from free-run juice of unsmoked grapes (unsmoked free-run treatment), 2) wine made from free-run juice of smoked grapes (smoked free-run), 3) wine made from free-run juice fermented on skins of unsmoked grapes (unsmoked free-run on skins) and 4) wine made from free-run juice fermented on skins of smoked grapes (smoked free-run on skins). These treatments were chosen to reflect commercial white and red production. For further details on winemaking procedures, please see the article.

• **Analyses**: Quantitative analyses were performed using an Agilent gas chromatograph coupled to a mass spectrophotometer. Guaiacol, 4-methylguaiacol, 4-ethylphenol, eugenol and furfural were quantified by the stable isotope dilution assay method.

•**Difference tests** were conducted using the triangle test method with 24 judges. Judges assessed two sets of wines; one set was wines made from free-run juice and one set was wines made from free-run juice on skins. Panelists smelled, but did not taste, the wines, then identified the one wine in each group of three that was different from the other two.

•**Aroma detection thresholds of smoke taint** were tested by 33 judges. The judges were presented samples of the smoked free-run juice diluted with base (unsmoked) free-run wine in concentrations spaced by a factor of three. Panelists smelled the wine (but did not taste it), and those who were able to detect the spike in varying concentrations were then tested at lower concentrations; those who couldn't detect the spike at any of the concentrations were tested at higher concentrations. The detection threshold of smoke taint in free-run juice on skins was tested the same way.

•**Results**: The sensory panel of 24 judges scored 22 correct responses for the free-run wine set and 24 correct responses for the free-run on skins wine set. This indicates these wines are significantly different at the 99.9% confidence level. The detection thresholds were determined to evaluate the intensity of the taint and the potential for its reduction by blending with untainted wines. The aroma thresholds were calculated to be dilutions of 1.6% for the smoked free run wine and 0.8% for the smoked free-run on skins wine, thus greatly limiting the options for blending of smoke tainted wine.

• Guaiacol, 4-methylguaiacol, 4-ethyl guaiacol, 4-ethylphenol, eugenol and furfural were detected in wines made from smoked grapes but not in wines made from unsmoked grapes. The concentrations of guaiacol and 4-methylguaiacol were higher in the free-run juice wines (1470µg/L Gu and 326µg/L 4-MGu) than in the free-run juice with skins wines (969µg/L Gu and 250µg/L 4-MGu). The fact that higher concentrations were found in the smoked free-run wines than the smoked free-run with skins wines suggests that, besides the skin exposure, there was permeation of smoke into the pulp of the berry. This permeation may reflect a high smoke exposure in this study and also the fact that the berries were treated after harvest, whereas earlier studies had berries treated in the field. These guaiacol and 4-methylguaiacol concentrations far exceed both detection threshold concentrations and concentrations commonly found in barrel-aged wines. [*Editor's note: it may be inaccurate to say the taint was in the pulp versus washed off the skins, since the researchers separated the pulp from the juice then added the skins back. To show it was in the pulp, they would have had to carefully peel the skins from the grapes or found another way to disallow any skin surface contact with the juice.*]

• Following the aroma threshold detection procedure, quantitative GC-MS analysis showed the detection thresholds of smoke taint established by the panelists correspond to guaiacol concentrations of 23µg/L and 4_methylguaiacol concentrations of 5µg/L in the smoked free-run wine. In the smoked free-run with skins, those concentrations were 7µg/L and 2µg/L, respectively. Because these concentrations are very near (or below) the detection thresholds reported for these compounds, the authors concluded that neither compound is solely responsible for the perception of smoke taint. Identification of further smoke-derived volatile compounds that contribute to smoke taint is the subject of ongoing research. However, guaiacol and 4-methylguaiacol are already useful as indicators of smoke taint.

• Several interesting things about post harvest smoke exposure came up in this study during the winemaking process. Smoke exposure resulted in an increased fermentation rate in free-run juice wines, but there was no effect on the free-run juice with skins wines. Smoked wines had higher alcohol content overall, and those fermented on the skins showed increased levels of brown pigments, as might be expected. However, all the smoked wines showed an increased browning compared to the corresponding unsmoked wines, irrespective of winemaking methods. The authors suggest that these observations may be explained by the effect of various compounds in smoke on membrane integrity within grape berries and skins.

• This is the first study to directly link the exposure of grape berries to smoke to the development of smoke taint in resultant wines. This is certainly a topic that will continue to be addressed as drought conditions lead to more wildfires closer to established vineyards around the world.

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