



Sensory impact of smoke exposure



Background

When vineyards and grapes are exposed to smoke this can result in wines with undesirable sensory characters, such as 'smoky', 'burnt', 'ashy' or 'medicinal', usually described as 'smoke tainted'. Consumers have been shown to respond negatively to smoke-tainted wines.

The compounds in smoke primarily responsible for the taint are the volatile phenols that are produced when wood is burnt. These can be absorbed directly by grapes and can bind to grape sugars to give glycosides that have no smoky aroma. Often these glycosides are described as smoke taint precursors. During fermentation (and also over time in barrel or bottle) these glycosides can break apart, releasing the volatile phenols into the must or wine, and allowing the smoky flavour to be perceived. These glycosides can also release the volatile phenols in the mouth during the drinking of wine, which may contribute to the perception of smoke taint.



Sensory thresholds of volatile phenols

Compound	Descriptors	Sensory detection threshold in red wine ($\mu\text{g/L}$)	Sensory detection threshold in water ($\mu\text{g/L}$)	Sensory detection threshold in 10% ethanol ($\mu\text{g/L}$)
Guaiacol	Smoky, medicinal	23 ^a	9.5 ^c	-
<i>m</i> -cresol	Tar, medicinal, phenolic	20 ^a	15 ^d	-
<i>p</i> -cresol	Tar, medicinal, phenolic	64 ^a	3.9 ^d	-
<i>o</i> -cresol	Tar, medicinal, phenolic	62 ^a	-	31 ^f
4-Methylguaiacol	Vanilla, clove, smoky	65 ^b	21 ^d	-
Syringol	Smoky, charcoal	-	-	570 ^c
4-Methylsyringol	Smoky, charcoal	-	10,000 ^e	

^aParker et al. 2012, ^bBoidron et al. 1988, ^cFerreira et al. 2000 ^dCzerny et al. 2008, ^eBurdock 2002, ^fLehtonen 1982

Guaiacol and *m*-cresol are the most potent volatile phenols and have the lowest sensory detection thresholds. *O*-cresol and *p*-cresol can also contribute to 'smoky' and 'medicinal' aroma and flavour, as well as a 'tarry' character. Syringol has a much higher sensory threshold, so is less likely to have a direct sensory impact, but it is often a good marker for smoke exposure.

If a wine has any of the volatile phenols present in concentrations above the sensory thresholds, the volatile phenols are likely to be perceptible. The volatile phenols can have a cumulative effect so that when several of these phenols are present below their threshold concentrations, together they can add up and contribute to 'smoky' and 'medicinal' aroma and flavour in the wine. For example, a spike of *o*-, *m*-, and *p*-cresol to a red wine at levels all below their individual threshold concentrations gives a noticeable 'medicinal' flavour (Mayr et al. 2014).

What does a sensory detection threshold number mean?

The most potent odorants in wine can be smelt at very low concentrations, and thus have very low thresholds. The threshold is determined by testing a number of people and then calculating a group threshold from the individual thresholds. **There is always variation in thresholds between individuals, with some tasters more sensitive to volatile phenols than others.** This variation in detection threshold is expected in any group of people, whether they are winemakers or consumers. The threshold indicates that 50% of a group are able to perceive the compound at or below the calculated value, and 50% above, and provides a guide to the potency of each compound.



Sensory impact of glycosides

Glycosides of volatile phenols can accumulate in grapes following smoke exposure (Hayasaka et al. 2010). Of the many different phenolic glycosides that have been found in grapes following smoke exposure, six have been selected as the best markers for smoke exposure: syringol gentiobioside, methylsyringol gentiobioside, phenol rutinoid, cresol rutinoid (includes *o*-, *m*-, and *p*-cresol rutinoids), guaiacol rutinoid and methylguaiacol rutinoid. The concentration of these phenolic glycosides are low in grapes that have not been exposed to smoke. Elevated concentrations of phenolic glycosides are good indicators of smoke exposure in the grapes. Syringol gentiobioside is a particularly sensitive marker of smoke exposure.

Glycosides readily transfer into juice and can persist in smoke-affected wines. During fermentation and wine ageing, the glycosides can breakdown and release volatile phenols (Hayasaka et al. 2010). High glycoside concentrations in grape berries thus indicate a risk of smoke-related sensory attributes in the wine made from these grapes.

Two specific glycosides (guaiacol glucoside and *m*-cresol glucoside) have been shown to impart 'smoky' and 'medicinal' flavour, by releasing guaiacol and *m*-cresol in-mouth (Parker et al. 2012). The threshold for guaiacol glucoside has been recently established to be 69 µg/L, tasted in water, approximately 10 times the threshold for guaiacol for the same panel (Parker et al. 2019); however, a wide range of individual sensitivities was seen. While the thresholds have not been determined for all the phenolic glycosides, it is reasonable to expect that the rutinoids of guaiacol and the cresols might also impart 'smoky' and 'medicinal' flavour.

Which compounds are responsible for 'smoky' aroma, 'bandaid' flavour and 'ashy' aftertaste?

Heavily smoke-affected wines tend to have higher concentrations of volatile phenols and glycosides. Aroma descriptors 'bandaid' and 'smoky burnt', and palate attributes 'bandaid', 'burnt/charred', and 'ashy aftertaste' were highly correlated in research studies with most of the volatile phenols and their glycosides. 'Bandaid' was particularly related to the concentration of the cresols, and 'ashy' aftertaste was correlated with most of the volatile phenols and the glycosides. (Parker et al. 2012; Mayr et al. 2014). Considering the sensory thresholds and these correlations, guaiacol, the cresols and the phenolic glycosides are probably the main drivers of 'smoky', 'ashy' and 'bandaid' flavours, with minor contributions from the other volatile phenols, and possibly other unknown components from the smoke.

What do consumers think about smoke-affected wines?

A recent blind sensory study showed that consumers gave very low liking scores for a smoke-affected wine compared to an unaffected wine. Even 25% of the smoke-affected wine in a blend strongly affected preference. It should be noted that the proportion of a smoke-affected wine that has a sensory impact in a blend will depend on the level of smoke compounds in the affected wine.

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