Technical notes

Smoke taint decision-making: simple steps for reliable sensory testing

Around the world, human-induced climate change is causing bushfires to become more frequent and severe. The smoke drift across vineyards from these fires is a threat to grape and wine quality. Chemical analysis of volatile phenols and their related glycosides in grapes will indicate the level of smoke exposure a vineyard has received. However, the presence of elevated levels of smoke markers – especially when only slightly elevated – can leave producers with difficult decisions to make regarding harvest, with high financial and emotional consequences.

Predicting how smoky a finished wine will taste based on chemical data alone is challenging. This is partly due to the varied background concentration of smoke compounds in unaffected grapes as well as the large variation in tasters' sensitivity to them in finished wine. Smoke compounds will also interact with the high number of other odorants in wines, making it very difficult to predict whether a certain concentration of smoke phenols will be perceptible in different wine varieties or styles.

Grape and wine producers need sufficient information to avoid picking and processing fruit that will give rise to smoke-affected wine, and also to avoid leaving grapes in a vineyard that would have produced wine with no noticeable smoke characters. Sensory analysis, if carried out properly, provides reliable data to aid in sound decision-making. This article provides a brief refresher on sensory analysis methods and describes straightforward steps that can be adopted in a winery or region for evaluating potentially smoke-affected wines. Figure 1 presents a summary of the main aspects to consider when running a smoke sensory test.

There is great variability in sensitivity to aroma compounds

A wine's aroma is signalled by olfactory receptor cells, while its flavour relies on signals from taste and touch receptors as well as the sense of smell. Humans' sense of smell arises from volatile compounds interacting with smell receptors during inhaling through the nostrils (ortho-nasal olfaction) and from the back of the throat when exhaling while tasting (retro-nasal olfaction). Volatile aroma compounds bind readily to these receptors connected to the olfactory bulb, and the signal is processed in the piriform cortex part of the brain before being integrated with taste and mouth-feel signals in the high cortical processing areas of the brain to form a wine's overall 'flavour'.

The sense of smell is of particular importance to smoke taint, as the known smoke-related compounds excite this sense. Although smoke-related glycosides (aromas bound to sugars) are often referred to as non-volatile in the scientific literature, they do in fact excite the sense of smell by breaking apart in the mouth during tasting and drinking, adding their volatile component to the free volatile pool in the wine, contributing further to the smoky flavour (retronasal aroma in this case) of the affected wine. Anecdotally, some smoke-affected wines may seem 'acrid', 'harsh' or 'bitter' on the palate; however, there is currently no scientific evidence that smoke-related compounds impart tastes or mouth-feel sensations directly, and no link between bitterness and smoke influence has been found (Parker et al. 2012).

There is very large genetic variation in the expression of the approximately 400 types of human olfactory receptors, with up to a third of the genes encoding these receptors differ-

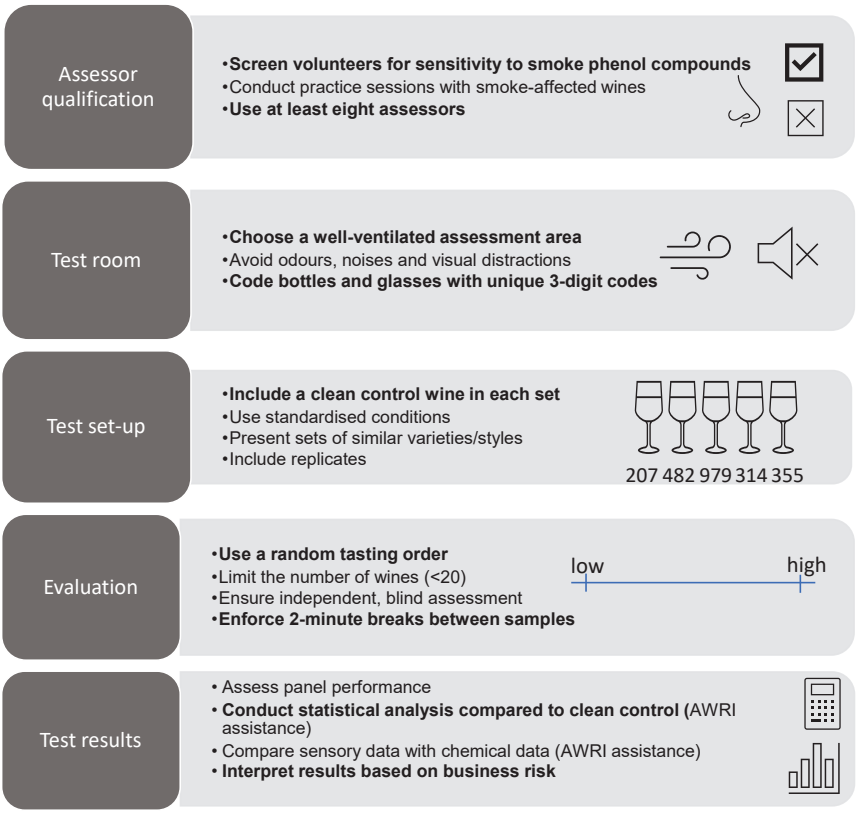

Figure 1. Summary of the main aspects required to conduct a reliable smoke panel rating sensory test. Critical steps are highlighted in bold.

ing between individuals (Mainland et al. 2014). This genetic variation is particularly important to recognise, as assessors with certain genotypes may result in phenotypes that have severely diminished sensitivity or might even completely lack the corresponding receptors in the nose for smoke compounds. They would therefore not be able to detect smoke taint, even if they are highly sensitive to other wine faults or taints.

Selecting smoke taint sensory assessors

A group of 'qualified' (screened and trained) assessors is necessary for smoke assessments as opposed to one or two highly 'expert' but 'unqualified' evaluators. When convening a smoke panel, whether within a company or for a regional panel, screening assessors for their ability to sense smoke compounds and providing evaluation training is extremely important. Winemaking experience, ability to give a quality score, or seniority do not influence the genetic lottery which dictates sensitivity to specific compounds – as such, staff from all departments of a business (e.g. office, laboratory, packaging) should be considered for participation on smoke taint panels, not just those with prior wine tasting experience.

Simple screening tests to 'qualify' an assessor for a smoke panel are essential, and should include a series of difference tests of volatile phenol mixtures and phenol glycosides in water. At least one 'practice' training session to familiarise assessors with the sensory protocol is highly recommended, and allows further checking of assessors' performance and their ability to discriminate. The AWRI can assist with providing samples and guidance for conducting screening and familiarisation sessions. Successful completion of both screening and training qualifies the assessor to participate in the panel. Insensitive assessors can be encouraged to take on other roles in the procedure such as coding glasses, preparing samples or data analysis. At least 8, and ideally 12, assessors are needed for calculation of an average taint intensity value and to conduct robust statistical analysis. This panel size will give sufficient sensitivity for a sensory test to detect low levels of smoke aroma and flavour.

Small panels of fewer than eight people can be used, but will be less sensitive and, rather than averages, a count of the number of positive responses is used, with criteria set for determining if samples are affected or not affected. This type of test has been found to give some inconclusive results and will not necessarily pick up low levels of taint. As such, it is not the AWRI's recommended approach.

Preparing samples for evaluation

Many smoke sensory assessments will involve small-lot 'bucket' ferments of grape samples. In this case, it is recommended that the grapes are tested for smoke phenol compounds and glycosides at the same time as the small-lot ferment starts, so both sets of data can be

used to make decisions. For regional panels, sample submission should be conducted with a level of confidentiality and there should be agreement in advance about how results will be shared.

Wines produced for sensory evaluation should be made following a standardised protocol and be free of lees sediment, with decanting prior to assessment desirable. A procedure and a demonstration video describing how to conduct small-lot fermentations are available from the smoke page on the AWRI website. Strong off-odours from winemaking artifacts (e.g. volatile acidity, reductive or oxidative odours) should be avoided if possible, as they can mask smoke character and greatly complicate the interpretation of sensory results. Wines produced using the small-lot ferment protocol generally come from quite unripe fruit – often sampled weeks before commercial harvest dates – and can be prone to overt sourness, bitterness and astringency as well as low fruit flavour. It is therefore recommended that assessments of these types of samples only evaluate the intensity of smoke characters and possibly general wine-like aroma or flavour, and avoid conflating the evaluation with quality scoring or other tasks. Comments on the tasting form should be encouraged to allow assessors to note other perceived off-odours, limiting what is known as 'attribute dumping'; for example, scoring a reductive wine as smoke-affected.

A person not participating in the evaluation should label and pour all the samples in private. Test wine bottles should be labelled with unique three-digit numbers as the assessors must not know the identity of the samples. These 'blinding' codes will also be written on the glasses presented for evaluation, using a white board marker. A uniform volume (30 mL) and temperature (room temperature) should be used. If possible, inexpensive plastic petri dishes (widely available online) could be used to cover the glasses to prevent wine odours from building up in the room.

It is critical that a randomised presentation order across tasters is used to minimise order effects. This can be achieved either by shuffling the coded wine glasses randomly after pouring or instructing each assessor to follow an individual sequence available online or by using sensory data acquisition software. The common left-to-right tasting or occasional wine show practice of having show judges start in different places or taste in opposite directions along a line-up of wines is not adequate in this instance. This practical but flawed approach does not overcome potential strong carry-over effects and most wines would be tasted beside the same two wines for nearly all assessors.

Tasters should face away from each other where possible, and the tasting room should have no background odours. Adaptation to background odours is very common. Con-

sider the sensory experience when first entering an exotic restaurant compared to half an hour into a dinner. The initial aromas disappear, blocked by the brain to allow for new signals to emerge. In a sensory test, when the background room aroma is the same as the target aroma, sensory adaptation will greatly diminish the overall sensitivity of the test. The authors have observed some smoke assessments run in a winery adjacent to a recently burnt-out vineyard, or in a room near an open fire at the cellar door: this is not good practice for assessing wines for smoke taint!

A negative control (a known unaffected 'clean' wine) must be included in each set of wines tasted and the assessors should be aware that negative controls will be included. A major psychological effect on sensory assessors – and especially those evaluating taints – is an expectation bias, which results in false positive scores. This effect cannot be entirely eliminated no matter how experienced or well-trained a panel is. For example, the authors recorded a panel of senior winemakers give a mean smoke score for a clean Chardonnay wine, made from fruit with no exposure to bushfire smoke, of 4.1 out of 10 during one evaluation. This type of bias can be reduced by not giving any background information to the assessors about the sample set; making sure assessors know that clean controls will be included and that some scores of zero for smoke are expected; ensuring that assessors are aware that their performance will be tracked; and, most importantly, comparing the overall results for each wine to that of a clean, unaffected wine assessed in the same set. Conclusions about potentially smoke-affected wines should be considered relative to the known clean control. The clean negative control wines should be of the same style and ideally same grape variety as the test wines; for example, if wines from small-lot ferments are being assessed, a wine from a small-lot ferment of known clean fruit should be included as the negative control.

A positive control, with obvious and known levels of smoke flavour could also be included, at least from time to time, to ensure assessors are still able to recognise smoke taint compounds. Some form of replication, presenting control samples twice for example, allows for assessment of panel performance and identification of assessors having a 'bad day'. Replicating the entire assessment should be considered, especially for ambiguous samples with large financial consequences at stake.

Conducting the sensory evaluation session

Prior to the evaluation, a panel leader should inform the panel of standard protocols as well as remind assessors that clean unaffected wines will be presented; that their performance will be tracked, and that individual assessor results will not be shared. Assessors should be

urged to focus on their senses and engage on the task at hand – not answering emails or calls during the assessment. The evaluation must be conducted by the assessors completely independently, without any talking about the samples or any other discussion during the tasting. Assessors should try to refrain from facial expressions or sounds of disgust when tasting so as to not influence other assessors.

The phenol glycosides in wines made from smoke-affected grapes can take up to several minutes to break down in-mouth and release their odour, so at least two minutes of rest is strongly recommended before moving onto the next sample, with assessors encouraged to rinse with water between samples. This will help protect against 'carry-over' of glycosides from a smoke-affected wine to the next sample in the evaluation. Strongly affected wines may take even longer to clear from the taster's senses, meaning that both water and palate 'cleansers' (unflavoured crackers) may be appropriate.

Scores (0-10) for the intensity of smoke taint are recorded using a line scale. The AWRI can provide access to sensory software for use by smoke sensory panels. Before any discussion is held among panel members, taint scores and comments should be submitted, with no further changes allowed to be made. No more than 20 samples are recommended to be assessed in a session, which will take at least one hour when appropriate breaks are enforced.

Participants should be thanked for their time and effort and given feedback promptly and regularly, to keep them motivated. A small treat following the tasting, such as chocolate, will help with motivation, especially if non-winemaker assessors are used. Individual results should be kept confidential. Poorly performing assessors should be informed tactfully but encouraged that they can improve and that poor performance in smoke taint assessments does not reflect general wine quality sensory skills.

Data analysis and interpretation

The AWRI can provide assistance to regional or company-based smoke panels with analysis of the data from sensory tests that are conducted using the recommended protocol. Briefly, an analysis of variance will be conducted by the AWRI on the smoke intensity scores with both wines and assessors as factors in the analysis, so that variation in assessors' use of the scale can be accounted for. If statistical evidence for a difference between the wines is found, a means comparison test is used to determine which samples differed from the clean control wine included in the set. A summary table will be provided to the panel organiser showing which samples are significantly different from the control.

When making business decisions based on sensory data, consideration should be given to both the identification of a statistically significant effect and the absolute mean intensity value obtained for a wine, relative to the control scores. For example, it may be found that a clean, known unaffected control wine has an intensity score of 1.7 on the 0 to 10 scale, while two 'significantly different' wines may have scores of 2.3 and 7.8, respectively. However, the interpretations might change if the clean control was instead scored 0.5 by the panel. Common scores for clean controls for the AWRI panel range from approximately 0.5 up to 2.0. Scores for clean control wines approaching 3.0 may be cause to investigate panel performance or the choice of control wine. Overtly 'flinty', 'struck-match', or heavily toasted oak characters should be avoided in control wines as these aromas may also confuse assessors.

A note on odour threshold values

Odour detection thresholds for aroma compounds can be misunderstood. There is sometimes confusion about what sensory thresholds for smoke-related phenol compounds mean and what conclusions can be drawn from them. An odour detection threshold test determines the lowest concentration of generally a single compound – in a particular wine, for a particular group of people – that is distinguishable from a blank sample. It is not an absolute threshold below which no human can detect the compound! In fact, threshold results are commonly reported as an average of the threshold measurements of a given group of assessors, which means 50% of the assessors detected the compound below this value, while the other 50% responded above this value. It is not uncommon for the range of sensitivity to span a 10- or 100-fold difference for the least to most sensitive people studied.

Caution should also be used when considering the concentrations of phenol compounds in a chemical analysis report in relation to sensory detection threshold values. If a phenol compound is found in a wine slightly below the sensory detection threshold, this does not mean it cannot have a sensory effect, especially if it is present with similar compounds at a similar levels. Likewise, a concentration of a smoke phenol slightly above the sensory detection threshold does not necessarily mean the compound will contribute smoky flavour, as the fruity or other characters in a wine can overwhelm the effect of the smoke phenols. These threshold values are not a replacement or proxy for the sensory practices described in this article. However, if concentrations are all well below the reported threshold, or well above, then there is a stronger position to consider their likely influence. The values also provide a good guide regarding the potency of one compound compared to another.

Conclusions

Although conducting formal sensory testing using a fairly large panel of assessors may seem daunting at first, these protocols are easily learnt and repeated. Several regional smoke sensory panels across Australia were set up and run in a short timeframe by local associations with support from the AWRI during the 2019–2020 season, following the widespread bushfires.

The AWRI has a dedicated smoke sensory panel, currently with a pool of 16 qualified assessors, who regularly assess wines from research studies, industry trials and wines submitted following smoke events. Several wine companies have also convened smoke sensory panels following the principles outlined in this article.

There is extensive material regarding smoke taint on the AWRI website (www.awri.com.au/industry_support/winemaking_resources/smoke-taint/) including demonstration videos and methods for conducting small-lot fermentations and smoke sensory assessments. The AWRI website also has a section on sensory methods. For further information or advice regarding smoke sensory panel set-up, running tests or inquiries on submitting wines to the AWRI smoke sensory panel, please contact the AWRI helpdesk team (helpdesk@awri.com.au), who can direct inquiries to the appropriate person.

To be most prudent, data collected from a smoke sensory panel should be coupled with chemical analysis to provide the richest, most reliable information possible to decision-makers. Predetermined action criteria regarding decisions to harvest or not harvest, based on the chemical data and the sensory test results should be formulated by considering business risk tolerance. Reliable sensory panel data will make dealing with these tough decisions much easier.

References

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