Stinky sulfur compounds in wine

The AWRI frequently receives queries about off-characters in wine caused by reduced sulfur compounds. In this column AWRI Senior Oenologist, **Adrian Coulter**, responds to typical questions asked about such characters.

What is the source of stinky sulfur compounds in wine?

The volatile sulfur compounds responsible for 'reductive' aromas in wine are mainly produced during fermentation and are derived from yeast metabolism, elemental sulfur residues from vineyard fungicides and the degradation of sulfur-containing amino acids. The amount and type of sulfur compounds generated during fermentation are dependent on the interplay between a range of factors, such as yeast strain, level of yeast assimilable nitrogen (YAN), pH, levels of precursors, temperature and, importantly, the overall reducing or oxidising capacity (redox potential) of the ferment (Müller *et al.* 2022).

Hydrogen sulfide (H_2S) and methanethiol (MeSH, sometimes referred to as methyl mercaptan) are two of the most common stinky sulfur compounds encountered during winemaking. The main sources of these compounds are the amino acids cysteine and methionine. Juices that contain high concentrations of these amino acids have the potential to produce high concentrations of H_2S and MeSH during fermentation. The H_2S and MeSH formed during fermentation will remain in the wine, either as free, loosely bound, metal-complexed or oxidised forms post-bottling (Bekker *et al.* 2018, Ferreira *et al.* 2017).

Why do stinky sulfur characters seem to come and go during winemaking and storage?

The free sulfur compounds and their metal-complexed and oxidised forms are interconnected through reversible redox equilibria, so a wine's redox potential determines the extent of each form present at any particular time (Ferreira *et al.* 2017). Under oxidising conditions (high redox potential), the free sulfur compounds are converted to the bound or oxidised forms, which can be odourless or less stinky, so a stinky aroma may 'dissappear' under these conditions. Conversely, under reducing conditions (low redox potential) these forms are reduced back to the free forms, so a stinky aroma can 'reappear'. In addition, the total amount of sulfur compounds can increase due to the metal-catalysed desulfurisation of cysteine and methionine (Ferreira *et al.* 2017).

Is it true that copper can make a sulfide problem reoccur?

While copper fining appears to be very effective at removing volatile sulfur compounds such as H_2S and MeSH straight after treatment, investigations over the past few years have shown that copper (and some other metals) can also promote the formation and release of these stinky compounds. Unfortunately, the reoccurrence of the malodours can occur several months after bottling when the oxygen introduced at bottling has been consumed and the redox potential has decreased (Bekker *et al.* 2018). This is a consequence of the reversible redox equilibria that copper is involved in mentioned above.

Historically, it was thought that the copper complexes formed after copper addition were removed by racking or filtration. However, this is not the case and there is typically a significant amount of the added copper left in the wine after fining and clarification (Clark *et al.* 2015). Therefore, copper fining just prior to bottling may increase the risk of the reoccurrence of sulfur off-odours 6 to 12 months later.

What is the best strategy for avoiding stinky sulfur compounds?

Firstly, it's important to ensure agrochemical withholding periods are adhered to in the vineyard to avoid late applications of fungicides containing elemental sulfur, which can lead to H_2S production. Must nitrogen deficiency is another important factor for H_2S production and yeasts can can vary greatly in their nitrogen requirement. Consequently, the nitrogen requirement of the yeast strain should be known and the must nitrogen content adjusted accordingly.

Suboptimal fermentations not only increase the risk of H_2S production, but also the risk of a sluggish or stuck fermentation. The risk of suboptimal fermentation can be decreased by good yeast preparation (see Cowey 2014). Once fermentation has commenced, a steady fermentation rate should be maintained by minimising sharp or large temperature fluctuations, which can stress yeast, as stressed yeast are more likely to produce H_2S. The risk of stressed yeast later in the ferment can be lessened by a single aeration treatment applied before mid-fermentation.

If 'reductive' characters are present towards the end of fermentation, when nitrogen additions are ineffective at inhibiting H_2S production, then it is advised to wait until the Baumé is zero, perform a copper trial and add the minimum amount of copper required to remove the off-odour. This is the best time to add copper, when live yeast are present to bind the excess copper remaining after fining. In the case of red wines, sparging with oxygen during fermentation appears to be effective in decreasing the risk of 'reductive' characters developing after bottling, although the combined use of oxygenation and copper finining is not recommended (Bekker *et al.* 2021).

Finally, if copper fining is necessary prior to bottling, given the concentration of copper is typically higher after copper fining than before, it may be beneficial to remove the residual copper by subsequently fining with a polyvinylimidazole-polyvinylpyrrolidone (PVI/PVP) co-polymer.

For further information on reductive characters or any other technical winemaking or viticulture question, contact the AWRI helpdesk on helpdesk@awri.com.au or 08 8313 6600.

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