Choosing the best remediation strategy to remove 'reductive' aromas


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Winemakers have a range of options available to them for the management of volatile sulfur compounds that cause unwanted 'reductive' aromas. A recent trial carried out a head-to-head comparison of five different treatments in Shiraz wine and found that macro-oxygenation was the frontrunner.

IN BRIEF

- **Winemakers use a range of strategies to manage unwanted volatile sulfur compounds (VSCs) associated with 'reductive' aromas in wine.**
- **These include diammonium phosphate (DAP) addition, copper fining, oxidative handling and racking, and fresh lees addition.**
- **An AWRI trial evaluated five different remediation strategies over 12 months.**
- **Treating wines early using macro-oxygenation was the most effective of the strategies trialled.**

INTRODUCTION

Managing 'reductive' aromas in wines remains an important consideration for winemakers. Compounds such as hydrogen sulfide (H_2S), methanethiol (MeSH) and thioacetates, for example, have significant impacts on wine aroma and consumer preference.

There are numerous strategies for the removal of these unwanted compounds, but each remediation strategy has strengths and weaknesses. For example, copper fining is only effective in removing thiols (plus disulfides after they have been reduced back to their original thiol products) but is not effective in remediating thioacetates or dialkyl sulfides. Copper fining may appear to be very effective immediately after treatment; however, if increased residual copper remains in wine post-bottling this may lead to the recurrence of 'reductive' aromas a few months or up to a year later (Bekker *et al.* 2018, Ugliano *et al*. 2011, Viviers *et al*. 2013). Similarly, supplementation with diammonium phosphate (DAP) has been shown to cause increased H_2S concentrations in certain instances (Ugliano *et al*. 2009, Ugliano *et al*. 2011, Waterhouse *et al*. 2016), even though DAP is commonly used with the goal of limiting the risk of H_2S formation. Yeast strains have different abilities to metabolise DAP and certain strains are more prone to produce VSCs (Ugliano *et al*. 2009, Ugliano *et al*. 2011, Waterhouse *et al*. 2016).

In other instances, the remediation of VSCs is an additional benefit to already well-established winemaking strategies. For example, using oxygen effectively during winemaking is beneficial for yeast health and promotes fermentation efficiency (Day *et al*. 2015). Recent studies have demonstrated that an additional benefit of using aerative winemaking techniques such as macro-oxygenation (see Table 1) during an active ferment is that they produce wines with low 'reductive' characters and increased 'fruity' aromas (Bekker *et al*. 2016). Other strategies such as adding clean lees or using lees products to 'freshen up' wines may be effective through binding of some of the unwanted sulfur compounds. However, there are risks of introducing VSCs through lees autolysis or through the action of active enzymes that could cleave sulfur-containing amino acids.

With all these remediation strategies available to winemakers, each with its own set of risks and benefits, it becomes challenging to select the most beneficial option. With this in mind, a study was designed to evaluate the relative effectiveness of five commonly used strategies for treating 'reductive' wines.

TRIAL DESIGN

Shiraz grapes from McLaren Vale were hand-harvested at commercial ripeness in 2017. Six sets of 40kg triplicate wines were prepared by WIC Winemaking Services using a standard winemaking procedure under particularly 'reductive' conditions to support increased production of VSCs. At the onset of H_2S production in the ferments, each triplicate set of wines received individual remediation treatments, as shown in Table 1.

RESULTS

Results from the trial showed significant differences in H_2S and MeSH concentrations across the treatments. The effects of the remediation strategies on H_2S and MeSH concentrations were the most apparent immediately after bottling (Figure 2) and became less pronounced after 12 months in bottle.

The 'Macro-Ox' and 'Macro-Ox + Copper' treatments were successful in decreasing H_2S concentrations in the wines (Figure 2a). Significantly lower H_2S concentrations were measured in the 'Macro-Ox' and 'Macro-Ox + Copper' treated wines when compared to the control wines (Figure 2a). The 'Copper'

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Table 1. Description of remediation treatments for volatile sulfur compounds compared in Shiraz ferments (40kg in triplicate for each treatment).

Treatment name	Treatment description
Control	No remediation treatment applied
DAP	Sequential DAP additions of 200mg/L and 150mg/L totalling 350mg/L of added DAP
Macro-Ox	Sparged with compressed air at a rate of 1L/min for 120 min for five consecutive days (Day 3 to Day 7) using a drop-in t-piece sparger fitted with four 2µm sinters (Figure 1)
Macro-Ox + Copper	Sparged with compressed air at a rate of 1L/min for 120 min for five consecutive days (Day 3 to Day 7) using a drop-in t-piece sparger fitted with four 2µm sinters; plus 0.15mg/L addition of $CuSO_4.5H_2O$ once ferments reached approximately 1Bé
Copper	1.0mg/L addition of $CuSO_4.5H_2O$ once ferments reached approximately 1Bé
Lees	Addition of 1.5L of fresh clean lees after inoculation with malolactic bacteria

treated wines did not show a significant decrease in H_2S compared to the control when measured post-bottling. Interestingly, the 'DAP' and 'Lees' treatments resulted in increased H_2S concentrations in these wines (Figure 2a). Similarly, 'Macro-Ox' and 'Macro-Ox + Copper' treatments were associated with significantly decreased MeSH concentrations when measured immediately post-bottling (P-values <0.001 and 0.002, respectively) (Figure 2b). Copper fining also resulted in significantly decreased MeSH concentrations immediately after bottling (P-value 0.018) (Figure 2b). Conversely, the 'DAP' and 'Lees' treatments resulted in significantly increased MeSH concentrations after bottling (Bekker *et al*. 2020).

To understand the sensory impacts of the different treatments, a detailed sensory descriptive analysis was carried out on the wines after 12 months of bottle storage. Significant differences were found among the treatments, mainly for attributes describing 'reductive' off-odours and 'fruit' notes. The wines treated with 'Macro-Ox' and 'Macro-Ox + Copper' displayed lower 'boiled egg' and 'drain' aromas, and higher 'red fruit' aromas (Figure 3, see page 44). The wines treated with 'Copper', 'DAP', and 'Lees' were characterised by 'drain', 'rubber' and 'boiled

Figure 1. Drop-in t-piece sparger fitted with four 2µm sinters, used for the macro-oxygenation treatments.

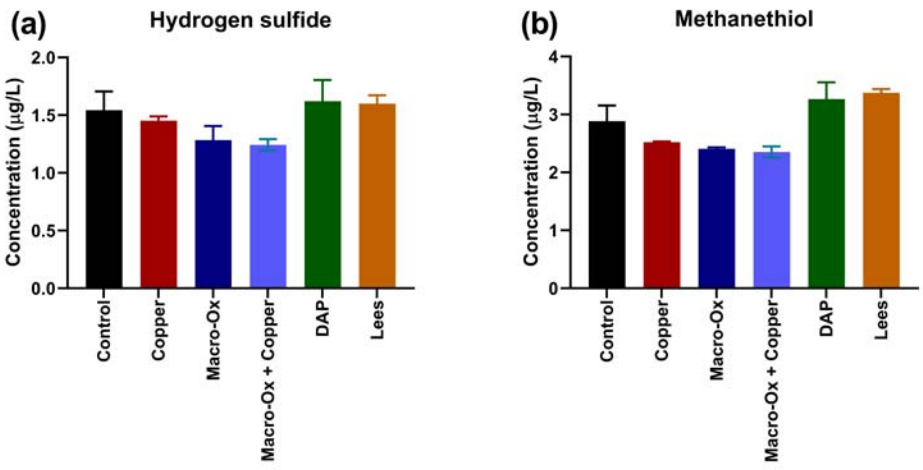

Figure 2. Hydrogen sulfide (a) and methanethiol (b) concentrations in Shiraz wines treated using copper addition (Copper), Macro-Oxygenation (Macro-Ox), combined copper fining and macro-oxygenation (Macro-Ox + Copper), DAP addition (DAP), and lees addition (Lees) measured immediately post-bottling. Details of treatments are provided in Table 1.

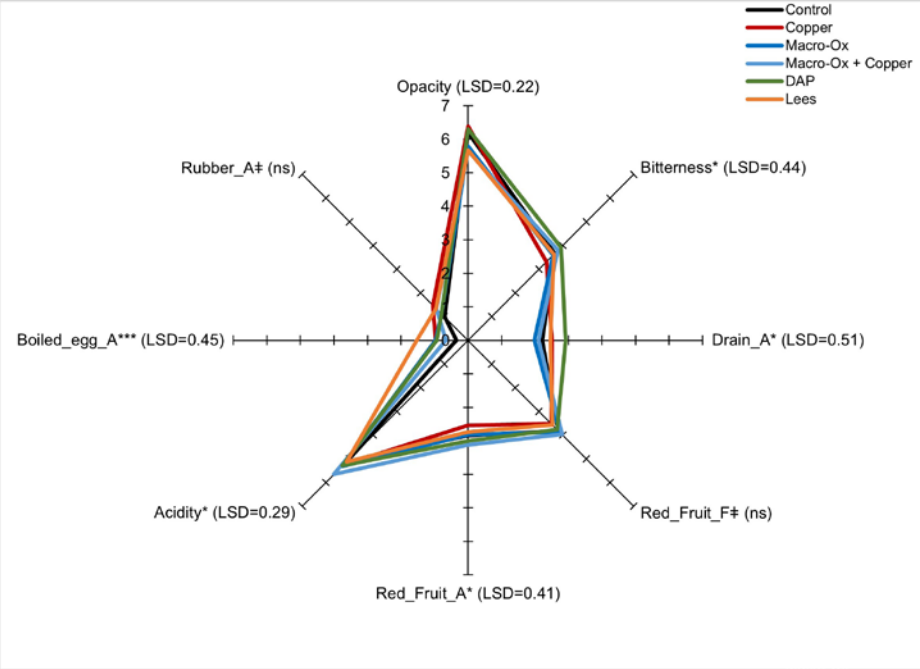

Figure 3. Mean sensory attribute intensity scores for significant attributes (*P < 0.05; **P < 0.01; ***P<0.001) and attributes approaching significance (‡ P < 0.16) for the 'reductive' aroma remediation treatments, assessed 12 months post-bottling. Least significant difference (LSD) (P=0.05) values are included for the significant attributes (P < 0.05).

egg' aromas, and these characters were especially apparent in the 'Lees' treated wines (Figure 3) (Bekker *et al*. 2020).

CONCLUSIONS

This work demonstrated that macro-oxygenation during fermentation was the most effective strategy over a period of 12 months post-bottling for remediating 'reductive' characters in wine with pronounced 'reductive' character, as confirmed with a detailed sensory analysis (Bekker *et al*. 2020). This strategy was associated with decreased H_2S and MeSH concentrations and their associated negative sensory attributes and increased 'fruity' notes. The combination of copper and macro-oxygenation was not any more successful than macro-oxygenation alone. Given that the addition of copper increases the risk of latent VSC production, this combination is not recommended. The DAP, copper fining, and lees treatments were less successful in this study, with the sensory profiles of wines remediated with these treatments showing increased 'reductive' characters.

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