Remediation of Smoke Tainted Wine using Molecularly Imprinted Polymers

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Introduction:

Smoke tainted wines can be unpleasantly smoky, ashy and dry, due to elevated levels of smoke-derived volatile phenols (i.e., guaiacol, 4-methylguaiacol, phenol, cresols, syringol and 4-methylsyringol), in free and glycosylated forms.

The addition of activated carbon remains one of the more effective approaches to remediation of smoke tainted wine, however, desirable wine aroma and colour compounds are often removed due to the lack of adsorbent selectivity. To address this shortcoming, a molecularly imprinted polymer (MIP) tailored to volatile phenols was developed (Figure 1) and evaluated as a selective adsorbent for smoke taint; one that can also be regenerated and reused.

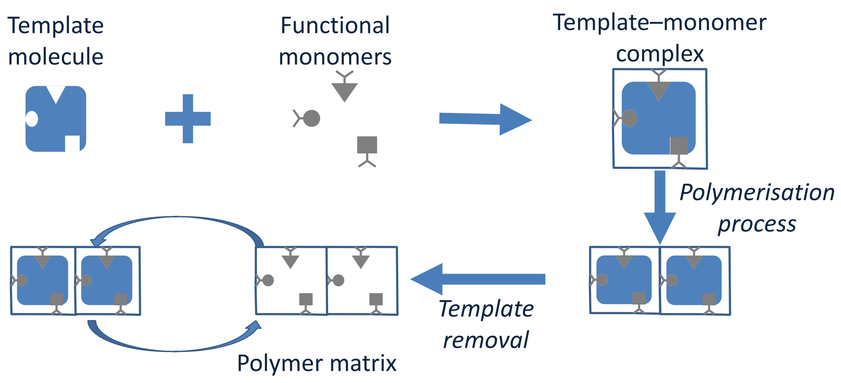


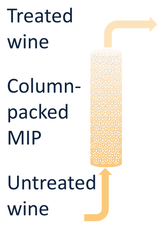
Figure 1. Schematic of molecular imprinting technology

Research methodology:

1. MIP addition during and post fermentation

MIPs (packed in mesh bags) were added to smoke-affected Semillon juice (~2 L) and Merlot must (~3 kg) at different time points during/post fermentation, with/without regeneration or replacement, and to unsmoked Semillion and Merlot wines (~2 L). Sensory analysis of wines determined the efficacy of remediation (**Figure 2**)

2. Semi-commercial scale, in-line MIP treatment

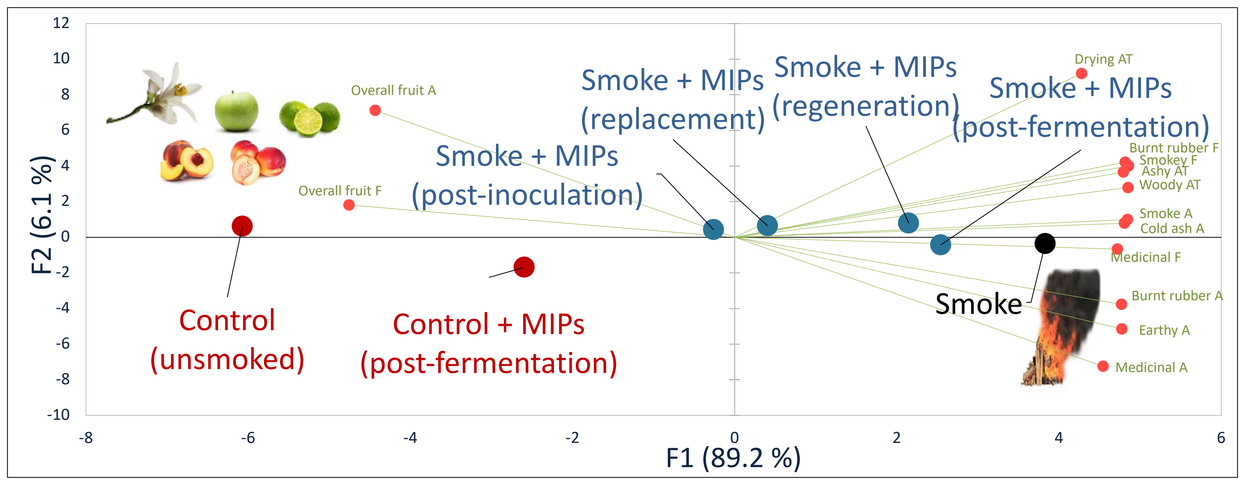


Smoke tainted Chardonnay, Cabernet Sauvignon and rosé wines (160 L each) were eluted through a column packed with MIPs (~2–3 L bed volume; one or two passes), with MIP regeneration applied between sequential wine treatments. Compositional analysis of eluent fractions (**Figure 3**) determined volatile phenol removal by MIPs, as well as their breakthrough (saturation).

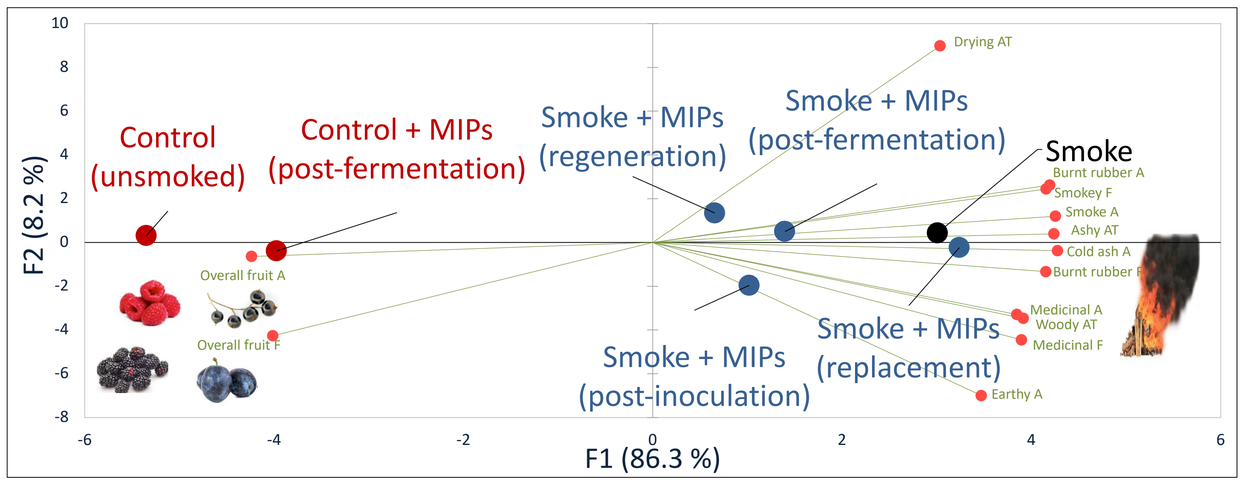
3. Kinetics of MIP adsorption of key volatile phenols

The kinetics of MIP adsorption of guaiacol, phenol and *m*-cresol was investigated by adding increasing amounts of adsorbent to model wines spiked with (individual) volatile phenols across a concentration gradient. Changes in volatile phenol levels were measured to determine MIP adsorption capacity and affinity (**Figure 4**).

Results:



Semillon



Merlot

Figure 2. PCA biplots of sensory attribute rating for Semillon and Merlot wines made from unsmoked and smoke-affected grapes with different MIP treatments

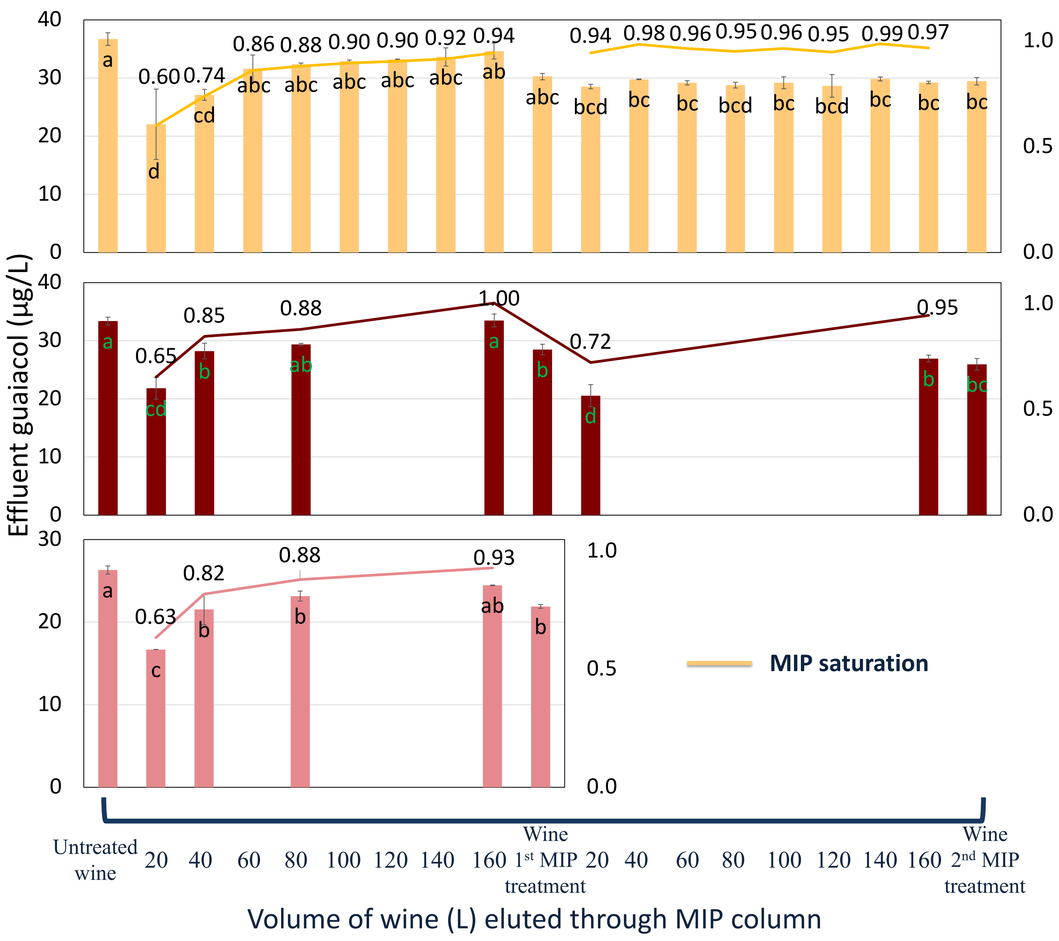


Figure 3. Saturation of column-packed MIPs with guaiacol following elution of smoke-affected Chardonnay, Cabernet Sauvignon, rosé wines

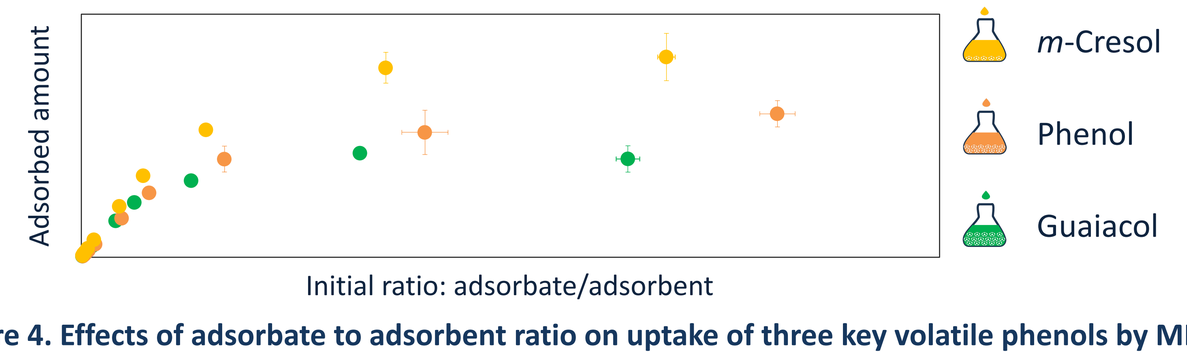


Figure 4. Effects of adsorbate to adsorbent ratio on uptake of three key volatile phenols by MIPs

Conclusion:

1. Addition of MIPs to juice or must during fermentation decreased wine volatile phenols and the sensory perception of smoke characters (**Figure 2**), however, elution of smoke tainted wine through a MIP column offers a more practical approach to remediation in an industrial setting.
2. MIPs were saturated by volatile phenols (guaiacol as an example) after elution of ~20 bed volumes of smoke tainted wine, but could be reused after regeneration (**Figure 3**).
3. MIP showed higher adsorption affinity and capacity for *m*-cresol than guaiacol or phenol (**Figure 4**).
4. Results suggest MIPs offer great potential for remediation of smoke taint in wine.

Publications:

[1]Huo, Y., Ristic, R., Puglisi, C., Wang, X., Muhlack, R., Baars, S., Herderich, M., & Wilkinson, K. (2024). Amelioration of Smoke Taint in Wine via Addition of Molecularly Imprinted Polymers during or after Fermentation. *Journal of Agricultural and Food Chemistry, 72,* 18121–18131.

[2]Huo, Y., Ristic, R., Savoie, M., Muhlack, R., Herderich, M., & Wilkinson, K. (2025). Adsorption Properties of Molecularly Imprinted Polymers Designed for Removal of Smoke Taint Compounds from Wine. *Food Research International, 206*, 116048.

FOR MORE INFORMATION

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