AWRI Australian Wine Research Institute

Fact Sheet

WINEMAKING

Treating smoke-affected wine with nanofiltration

Background

When grapes are exposed to smoke, they can absorb volatile phenols, which bind to sugars in the grapes forming non-volatile phenolic glycosides. In juice and wine, both volatile phenols and their glycosides can cause unpleasant 'ashy' and 'smoky' sensory sensations and a lingering aftertaste, commonly described as 'smoke taint'.

What is nanofiltration and how can it be used to mitigate smoke taint?

Nanofiltration is a process similar to reverse osmosis (RO) but which uses a different type and size of membrane. Nanofiltration works by pushing wine across a semi-permeable membrane (i.e. a nanofilter) with a molecular weight cut-off of approximately 150-300 Da, whereas RO membranes have a much lower molecular weight cut-off (approximately 100 Da), allowing only smaller molecules such as water and ethanol to pass through. Molecules with a molecular weight below 150-300 Da, such as the volatile phenols implicated in smoke taint, will pass through the nanofiltration membrane into what is referred to as the permeate. This permeate is subsequently passed through an absorbent material, to selectively remove the unwanted volatile phenols, before being added back to the tank containing the wine (Figure 1). This treatment for smoke-affected wines has previously been shown to significantly reduce the concentrations of volatile phenols and intensity of smoke-related sensory attributes (Fudge et al. 2011).

Phenolic glycosides are too large to pass through the membrane and remain in the retentate (i.e. the wine that goes back into the tank). The composition of the absorbent material used to remove the unwanted compounds from the permeate is often proprietary information owned by the commercial supplier but it is typically a resin or a type of activated carbon. How much permeate needs to be generated and treated to achieve the desired result depends on the level of smoke compounds in the wine.

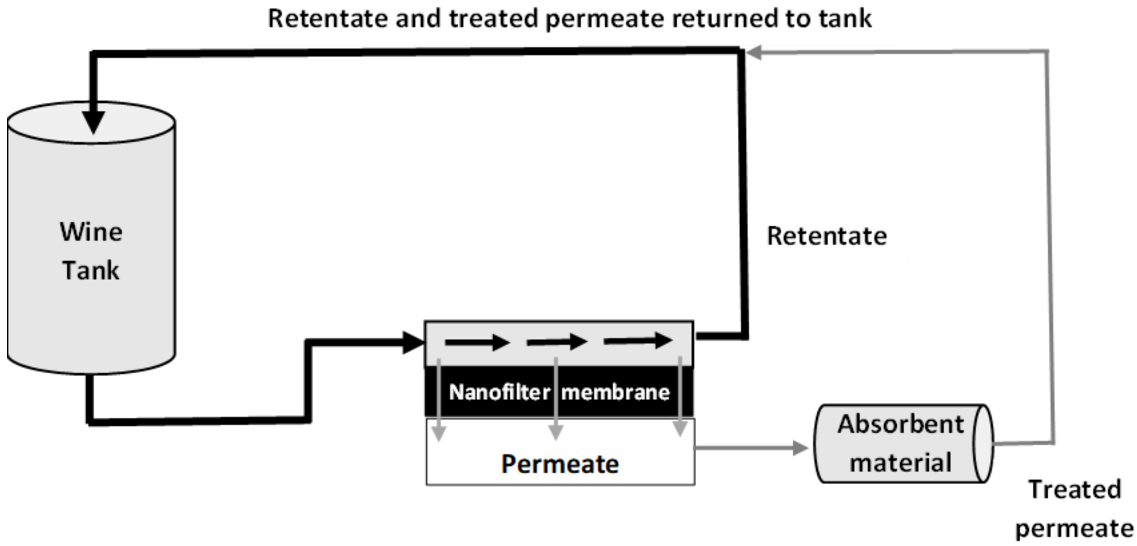

***Figure 1**. Schematic of the nanofiltration process used to treat smoke-affected wine. Adapted from Fudge et al. 2011.*

Assessing performance

Smoke-affected Tempranillo, Gamay, Pinot Noir, Shiraz and Muscat wines were selected and underwent production-scale nanofiltration treatment in a commercial winery. The effectiveness of nanofiltration to treat 2.5 kL of smoke-affected wines at 15-16°C, with or without prior glycosidase treatment, was evaluated by chemical and sensory analysis.

Since the nanofiltration process typically does not effectively remove phenolic glycosides as they are too large to pass through the membrane, treatment with glycosidase enzymes prior to nanofiltration was also investigated with the aim of releasing additional volatile phenols via cleavage of the sugar units from the phenolic glycosides.

The sum of the volatile phenols (n=7) and sum of the phenolic glycosides (n=6) for each of the control and treated wines, along with the mean ratings for smoke aroma and smoke flavour are provided in Table 1. Nanofiltration of five smoke-affected wines (by supplier 1) had little to no impact on the concentrations of volatile phenols and phenolic glycosides. The treated wines were therefore not significantly different for smoke aroma and smoke flavour compared to the control wines. Activated carbon (the absorbent used by supplier 2) was more effective at reducing the volatile phenols in the Shiraz wine than the proprietary resin used by supplier 1.

Glycosidase treatment led to a 55 and 62% reduction in glycosides for the Tempranillo and Pinot Noir wines, respectively, and a significant increase in smoke flavour perception compared to the control wine for the Tempranillo. There was a slight increase in the sensory ratings for the smoke attributes for the Pinot Noir wine compared to the control; however, this increase was not statistically significant.

Table 1. *Sum of the volatile phenols, phenolic glycosides and mean ratings for smoke aroma and smoke flavour for each of the wines*

Treatment	Sum of volatile phenols	Sum of phenolic glycosides	Smoke aroma	Smoke flavour	Significantly different from the control**?
Tempranillo wines					
Pre-NF	26	126	0.89	1.39	-
Post-NF	25	127	0.45	0.87	No
Glycosidase*	25	57	1.58	2.87	Yes, flavour only
Glycosidase* + NF	27	61	1.62	2.50	Yes, flavour only
Gamay wines					
Pre-NF	25	107	1.76	2.52	-
Post-NF	25	107	0.65	1.02	No
Pinot Noir wines					
Pre-NF	43	55	1.18	2.20	-
Post-NF	38	56	1.88	3.21	No
Glycosidase*	43	21	1.77	2.75	No
Glycosidase* + NF	46	22	1.31	2.62	No
Shiraz wines					
Pre-NF	66	188	0.41	0.54	-
Post-NF Supplier 1	72	192	0.85	1.24	No
Post-NF Supplier 2	44	175	0.75	1.06	No
Muscat wines					
Pre-NF	36	230	1.27	1.25	-
Post-NF	33	239	0.78	1.40	No

*Enzyme used was Trenolin® Bouquet PLUS from Erbslöh, 15 mL/hL; NF = nanofiltration;

**Based on sensory analysis ratings for smoke aroma and smoke flavour. Sum of volatile phenols = additive concentrations (in µg/L) of 4-methylguaiacol, guaiacol, *o*-cresol, *p*-cresol, *m*-cresol, syringol and 4-methylsyringol; Sum of phenolic glycosides = additive concentrations (in µg/L SyGG equivalents) of Syringol gentiobioside (SyGG), methylsyringol gentiobioside (MSyGG), phenol rutinoside (PhRG), cresol rutinoside (CrRG), guaiacol rutinoside (GuRG) and 4-methylguaiacol rutinoside (MGuRG).

Evaluation of permeate samples from supplier 1

While it was expected that nanofiltration would not reduce the concentrations of phenolic glycosides, it was a surprising result that the nanofiltration process also had little impact on the volatile phenols, particularly for supplier 1. Subsequently, a selection of permeate samples collected during the nanofiltration process conducted by that supplier were investigated further to determine:

(i) If the volatile phenols were penetrating the nanofiltration membrane (i.e. were they present in the 'permeate in' sample?)

(ii) if they were, whether subsequent passage through the resin had any impact on removing them (i.e. were the concentrations in the 'permeate out' sample lower compared to the 'permeate in' sample?).

Table 2 lists the concentrations of volatile phenols contained in the permeate samples, along with those previously measured in the control Gamay and Shiraz wines (i.e. pre-nanofiltration).

Table 2. *Concentration of volatile phenols in the control Gamay and Shiraz wines and permeate samples*

	Concentration (µg/L)							
Sample	**4-Methyl guaiacol**	**Guaiacol**	**o-Cresol**	***p*-Cresol**	***m*-Cresol**	**Syringol**	**Methyl Syringol**	**Sum**
Gamay								
Control wine	1	5	3	6	3	7	<1	25
Permeate in	<1	3	3	3	2	2	<1	13
Permeate out	<1	3	3	3	2	2	<1	13
Shiraz								
Control wine	4	17	3	3	2	26	11	66
Permeate in	2	13	3	2	2	12	3	37
Permeate out	2	12	3	2	1	12	2	34

The 'permeate in' samples contained approximately half the concentration of volatile phenols observed in the control wines (i.e. 52% and 56% for Gamay and Shiraz, respectively) and as such there was some passage of volatile phenols across the membrane used in the nanofiltration process. However, there was little to no reduction in the concentrations of volatile phenols between the 'permeate in' and 'permeate out' samples, suggesting that passage through the resin did not reduce their concentrations.

Conclusions/recommendations

In this series of trials with commercial wine producers, the nanofiltration process had little impact on the concentrations of the targeted smoke-related compounds in the five smoke-affected wines investigated, with the exception of treatment of the Shiraz wine by supplier 2. None of the treated wines were found to be statistically different to the control wine for smoke aroma and smoke flavour. The nanofiltration process alone did not successfully remediate the smoke characters in the wine and evaluation of permeate samples collected during the process (supplier 1) indicated that the absorbent material was failing to remove the volatile phenols. The absorbent material used by supplier 2 (an activated carbon) was more effective at reducing the volatile phenols in the Shiraz wine than the proprietary resin used by supplier 1. Consequently, optimising the absorbent material for removal of volatile phenols is the focus of current and future research. Technologies are constantly advancing and new materials being developed, providing the basis for ongoing research into smoke taint remediation using nanofiltration and other membrane technologies. There may be opportunities in the future to re-assess their effectiveness in remediating smoke-affected wine.

Producers should undertake their own independent assessments when considering treatments to mitigate the chemical and sensory impacts from smoke exposure.

Reference and further reading

Wollan, D. 2022. Membrane and other techniques for the management of wine composition. Reynolds, A.G. (ed.) *Managing Wine Quality, Volume 2. Oenology and Wine Quality, Second Edition* Cambridge, United Kingdom: Woodhead Publishing Ltd: pp. 183-212.

Fudge, A.L, Ristic, R., Wollan, D., Wilkinson, K.L. 2011. Amelioration of smoke taint in wine by reverse osmosis and solid phase adsorption. *Aust. J. Grape Wine Res.* 17: S41–S48.

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