Effects of fermentation temperature on red wine composition

In this column, **Peter Godden** concludes a series examining the effects of winemaking variables on red wine composition, by examining fermentation temperature.

Background

During tastings of the AWRI's winemaking treatment trial wines held with winemakers around Australia, the red wines produced with increased fermentation temperature were almost universally the most preferred. This column examines how a relatively small winemaking change can result in a large difference in wine composition and sensory properties.

What happens to red wine phenolic profiles when fermentation temperatures increase?

The contribution of grape-derived phenolics to the colour, tannin concentration, overall quality and ageing potential of red wines has been established by numerous studies. While the initial concentration of phenolic compounds in grapes has some relationship to the final phenolic composition of wine, fermentation temperature and the extent and duration of cap management have been shown to strongly influence phenolic extraction during winemaking, and the phenolic composition of wines over time.

Studies on the extraction of phenolics during red winemaking were conducted at the University of California, Davis, in the 1950s and 1960s by Maynard Amerine and Cornelius Ough. However, as reported by Casassa and Harberstson (2014), Eugene Hilgard, also working at the University of California, had established in 1887 that the maximum extraction of colour occurred before that of tannins, and that maximum colour was obtained earlier at higher temperatures.

Not all phenolics are extracted at the same rate during fermentation, and while the rate of extraction of some compounds increases with increasing fermentation temperature, the final concentrations may be unaffected. For instance, Lerno *et al.* (2015) found that increased fermentation temperature increased the rate of extraction but not the final concentration of skin-derived phenolics, whereas for seed-derived phenolics both the rate and final concentration increased. It was also concluded that must temperature was more important than the cap temperature in determining the extraction of phenolics.

Is the non-phenolic composition of red wines affected by fermentation temperature?

The effect of increasing temperature on the concentration of several yeast-synthesised wine components was examined by Rollero *et al.* (2015). Increases in some esters were found, including isoamyl acetate ('fruity', 'banana', 'pear') and ethyl octanoate ('cherry'), with the production of succinic acid and glycerol also positively correlated with increasing fermentation temperature. Lower concentrations of ethanol and certain volatile compounds with increasing temperature are also common, largely attributed to increased volatilisation during fermentation. Small increases in wine pH are also reported, presumably due to increased extraction of potassium from grape skins at higher temperature.

The effects of higher temperature on wine phenolics in the AWRI red winemaking treatment trials

The changes observed in wine phenolics between two fermentation temperatures in the AWRI's trials are presented in Table 1 and show increases in all phenolic measures for all varieties. The percentage increases with Pinot Noir were less than those seen for Shiraz and Cabernet Sauvignon, which might be accounted for by a lower initial concentration of phenolic compounds in the grapes, as well as a smaller difference in fermentation temperatures. The largest changes in phenolic composition were seen with the Shiraz wines, with total phenolics increasing by 42% and tannins by 107%, when the mean fermentation temperature was increased from approximately 25°C to 33.5°C. In general, the percentage increases in wine phenolics seen in these three sets of wines are larger than reported in many studies. One possible explanation is that the starting concentration of phenolics in the grapes might have been higher than for grapes used in other studies. ▸

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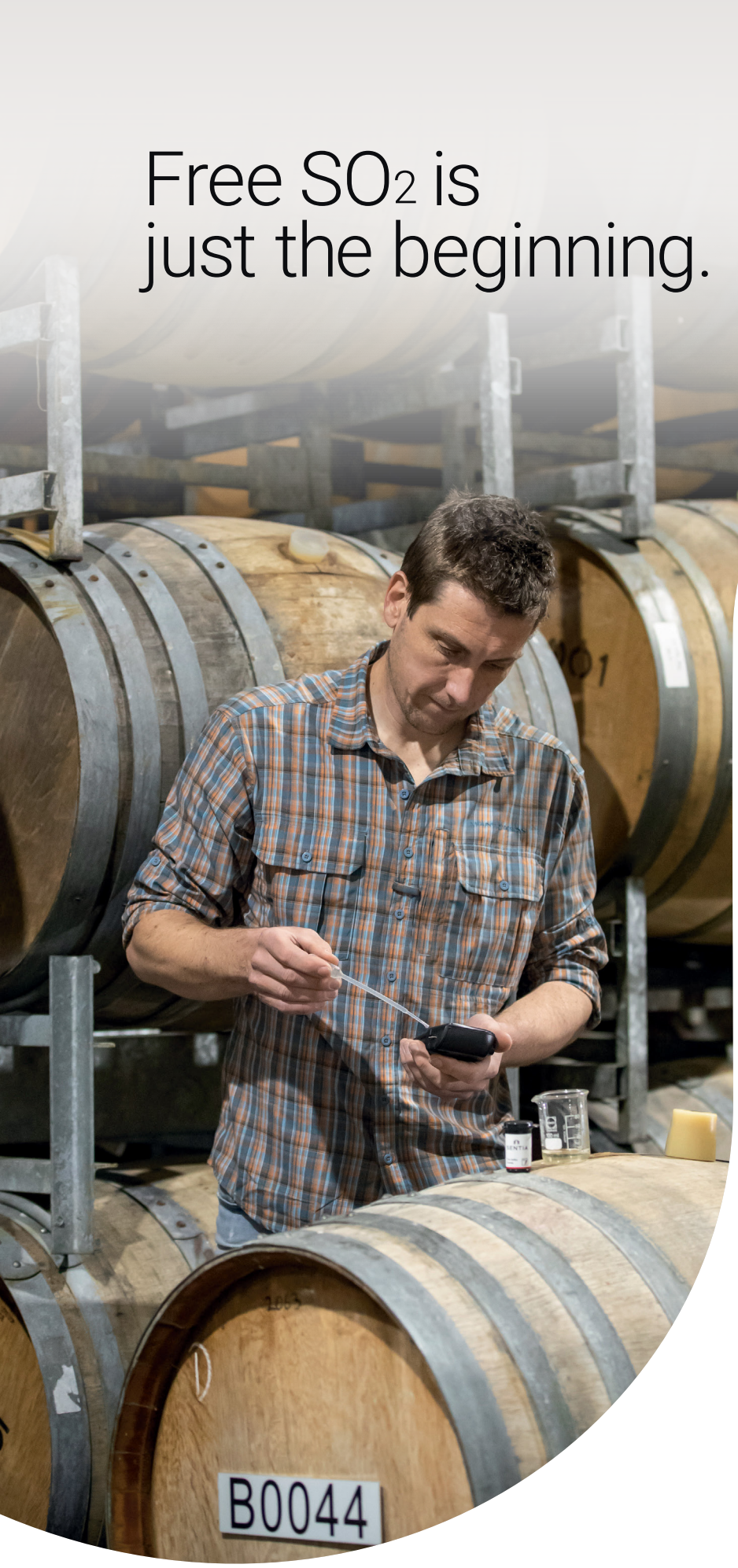

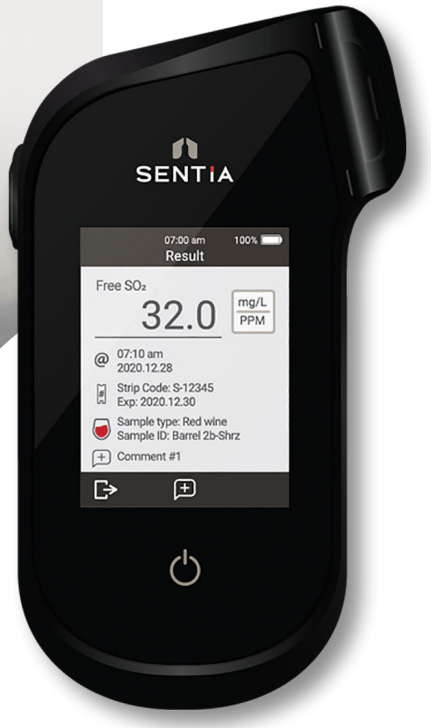

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Table 1. Comparison of phenolic composition of Pinot Noir, Shiraz and Cabernet Sauvignon wines fermented at different temperatures in AWRI winemaking treatment trials

	Pinot Noir (2016)			Shiraz (2017)			Cabernet Sauvignon (2018)		
Phenolic measure	Control ferment 24 - 26°C, 10-day ferment	Warm ferment 24 - 32°C, 7-day ferment[a]	% increase	Control ferment 24 - 26°C, 12-day ferment	Warm ferment 32 - 35°C, 10-day ferment[b]	% increase	Control ferment 24 - 26°C, 14-day ferment	Warm ferment 32 - 34°C, 10-day ferment[c]	% increase
Total phenolics (AU)	22	23	4.5%	31	44	41.9%	44	55	25.0%
Total anthocyanins (mg/L)	115	121	5.2%	415	556	34.0%	476	508	6.7%
Tannin (mg/L)	480	641	33.5%	576	1192	106.9%	1,336	2,167	62.2%
Non-bleachable pigments (AU)	0.36	0.42	16.7%	1.35	1.83	35.6%	2.7	3.7	37.0%

a One additional pump-over was performed each day compared to the control, so that both the control and warm ferment received approximately the same amount of pumping-over in total.
b, c Additional plunging was performed so that both the control and warm ferment received approximately the same amount of plunging overall.

What are the practical considerations and potential risks?

Increased fermentation temperature increases the rate of fermentation, thereby further increasing temperature in a positive feedback loop. Consequently, there is a greater risk of fermentations becoming uncontrollable at higher temperature if insufficient cooling capacity is available or if the fermentations are not actively cooled, and this can result in undesirable sensory characters. Pumping the fermenting liquid though a heat exchanger and distributing the cooled liquid over the cap is the most effective way of cooling a ferment. In addition, while pumping over, rack-and-return, and to a lesser degree plunging may all help to dissipate heat, they also introduce oxygen which may stimulate yeast and result in an increased fermentation rate.

Conclusion

Other articles in this series have discussed techniques which also increase red wine phenolics, including pre-ferment cold maceration, post-ferment extended maceration and saigneé. While each of those treatments confer different sensory properties, if the primary aim is to increase the concentrations of total phenolics, anthocyanins and tannin, increasing fermentation temperature to between 30°C and 32°C is a simple, relatively low risk and cost-effective method of achieving that aim compared to other methods.

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