Trends in the composition of Australian wine 1990-2021

Part three: free, total and bound sulfur dioxide concentrations, and the ratio of free to total SO_2 concentrations

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This article is the third in a three-part series presenting data on the composition of Australian wine. The first part (published in the Summer 2023 issue) provided an introduction to the data and discussed titratable acidity and pH while the second (published in the Autumn 2023 issue) covered alcohol and glucose and fructose. This third and final part discusses free, total and bound SO_2 as well as the ratio of free to total SO_2.

DATA PRESENTATION

The data are presented in two formats, interval plots and box plots, with the plots for white and rosé wines shown in green and the plots for red wines shown in red. The interval plots show the mean of the data for each year. In the box plots, the centre horizontal line marks the median of the data for each year. More details about the data presentation can be found in Godden and Wilkes (2023a).

RESULTS AND DISCUSSION

The plots presented here summarise the analytical results recorded in the database when they were generated in mid-2022. For each compositional variable, plots are presented for white and rosé wines combined, and for red wines. Data for rosé wines were first included in this series by Godden *et al*. (2015) from the 2004 vintage onwards.

In this article the approach taken to measures of SO_2 follows that taken by Godden *et al.* (2015). While the measures of several of the other analytes discussed in this three-part series may change over time in bottled wine, those changes are generally so minor that overall trends are not altered. However, that is not the case with SO_2, and consequently data has been restricted to that which was analysed within one year of the vintage year for white and rosé wines, and within two years for red wines. While this approach has reduced the number of data

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IN **BRIEF**

- **Since 2015, concentrations of free SO_2 have stabilised in narrow bands of between 27.1mg/L and 28.8mg/L for white and rosé wines, and 24.5mg/L and 25.0mg/L for red wines.**

- **The means of total SO_2 concentrations have shown steady declines: for white and rosé wines, from a peak of 129.5mg/L in 2012 to 108.4mg/L in 2021; for reds, from a peak of 86.7mg/L in 2011 to 61.6mg/L in 2021.**

- **The mean concentrations of bound SO_2 peaked at 101.4mg/L for white and rosé wines in 2010, and at 62.1mg/L for red wines in 2009. In 2021, bound SO_2 concentrations for white/rosé wines and red wines fell to 80.3mg/L and 36.6mg/L, respectively.**

- **In 2021, the mean ratio of free-to-total SO_2 increased to 0.28 for white and rosé wines, and to 0.45 for red wines.**

- **While the data indicates excellent SO_2 management by Australian winemakers, the actual free and total SO_2 concentrations at bottling have probably reduced to a point close to the minimum concentrations recommended by the AWRI.**

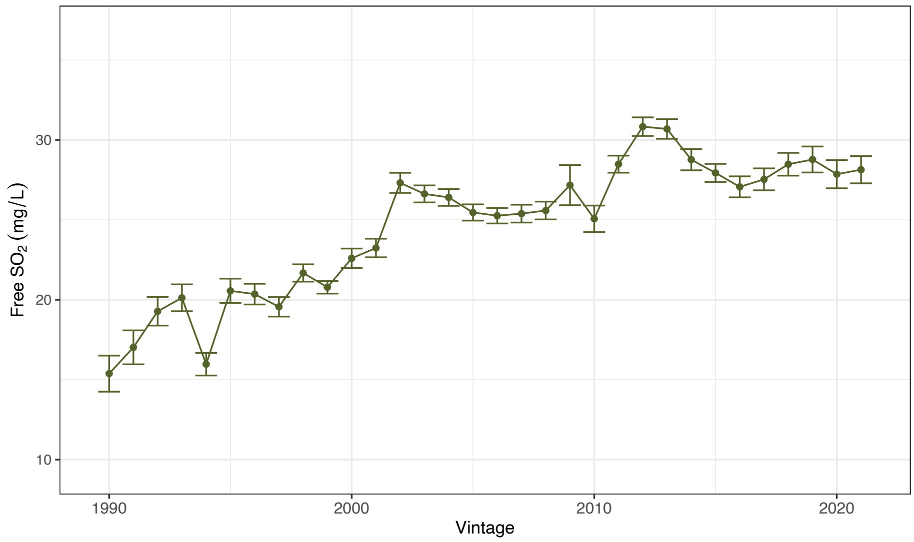

Figure 1a. Mean free SO_2 concentration in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

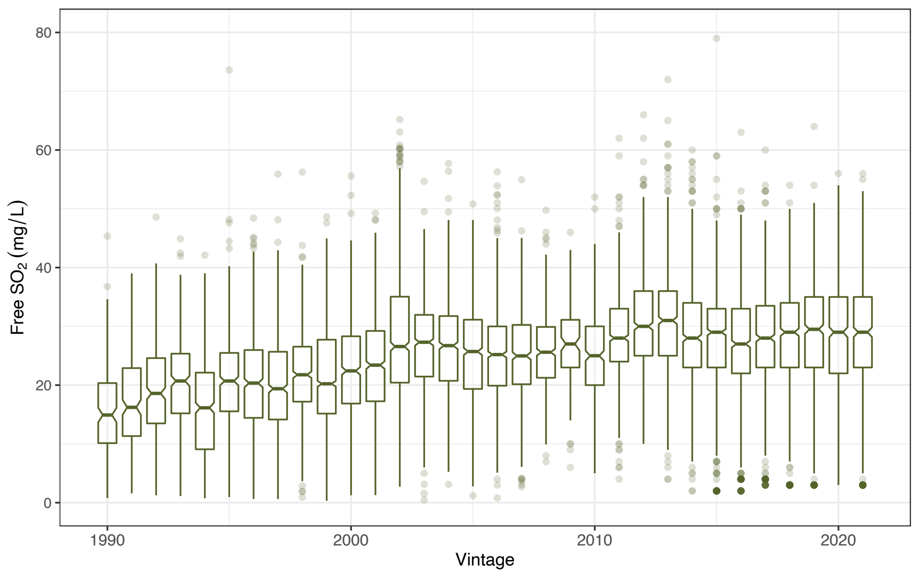

Figure 1b. Median (horizontal line) and distribution of free SO_2 concentrations in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

points available for the four SO_2 measures discussed, it has also reduced the impacts of variability in the data arising from differing time intervals between bottling and the time of analysis. Consequently, the current approach is considered to provide a clearer indication of SO_2 conentrations at the time of packaging and enables more valid comparisons between vintages than the approach taken prior to 2015. However, caution should therefore be exercised when comparing the SO_2 data published here and in Godden *et al*. (2015) to that in the publications prior to 2015.

SO_2 is the most common wine additive because of its combined antimicrobial and antioxidant properties. As previously stated, compared with the other compositional variables reviewed, SO_2 concentrations are the most prone to change over time in bottle due to the compound's sacrificial role in countering oxidation.

Under the Australia New Zealand Food Standards Code, section 4.5.1 Wine Product Requirements, the maximum concentration of SO_2 permitted in wines for sale in Australia is 250mg/L for wines containing up to 35g/L of sugar and 300mg/L for wines containing more than 35g/L of sugar.

For all four of the measures of SO_2 discussed here, for both white/rosé wine and red wines, the plots present an extremely positive picture regarding the manner in which Australian winemakers are managing SO_2.

Since the 2015 publication the concentrations of free SO_2 have stabilised in narrow bands of between 27.1mg/L and 28.8mg/L for white and rosé wines, and 24.5mg/L and 25.0mg/L for red wines (Figures 1a and 2a, page 34). The distributions of mean free SO_2 concentrations (Figures 1b and 2b) show reductions in the number of outliers at the upper end of the distributions, and a slight expansion in the proportion of wines represented by the second and third quartiles (the box), particularly for red wines (Figure 2b). Interestingly, a substantial number of outliers at the lowest end of the distribution are also evident. These are wines with negligible free and total SO_2 and are more evident on some of the other SO_2 plots discussed

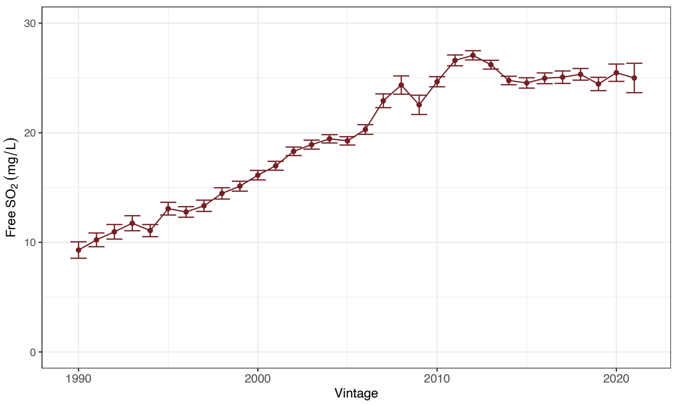

Figure 2a. Mean free SO_2 concentration in red wines 1990-2021.

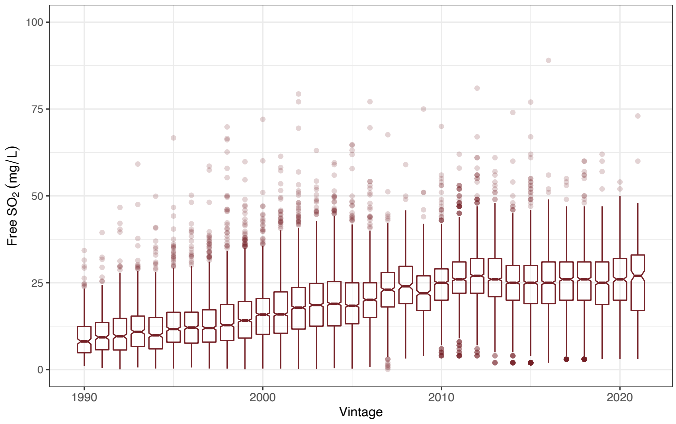

Figure 2b. Median (horizontal line) and distribution of free SO_2 concentrations in red wines 1990-2021.

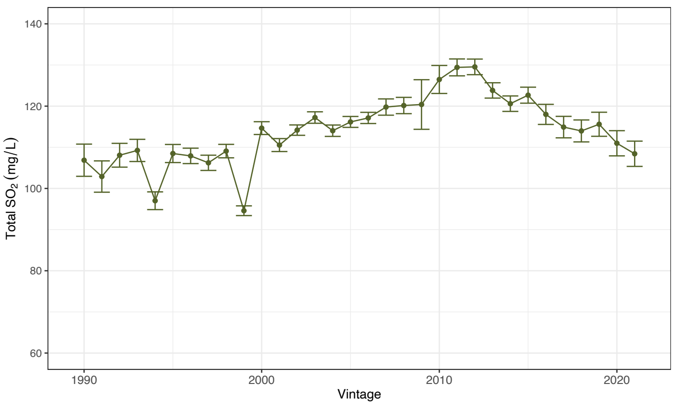

Figure 3a. Mean total SO_2 concentration in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

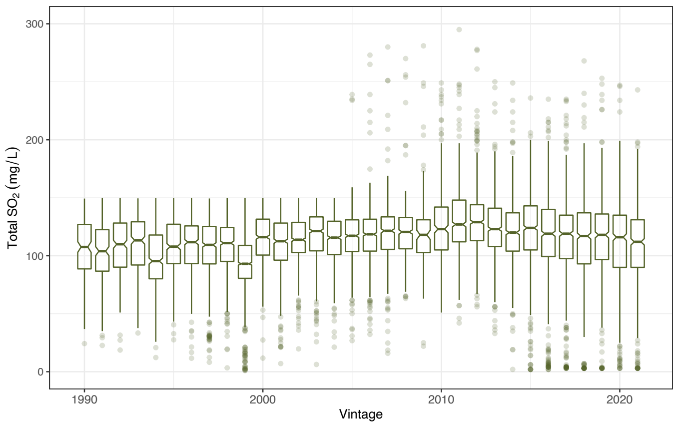

Figure 3b. Median (horizontal line) and distribution of total SO_2 concentrations in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

below. They are thought to represent the trend pursued by some winemakers of low intervention winemaking, sometimes referred to as making 'natural' wines.

The means of the total SO_2 concentrations are presented in Figure 3a for white and rosé wines, and 4a for red wines. Both show steady declines in total SO_2; for white and rosé wines from a peak of 129.5mg/L in 2012 to 108.4mg/L in 2021, and for red wines from a peak of 86.7mg/L in 2011, to 61.6mg/L in 2021.

The distributions of total SO_2 (Figures 3b and 4b) graphically illustrate the low-intervention wine cohort as outliers at the bottom of the distributions. Otherwise, some differences in the distributions are evident between white/rosé wines (Figure 3b) and red wines (Figure 4b). White and rosé wines show a widening of the distributions from 2012 onwards, especially for the first and fourth quartiles (i.e. the whiskers above and below the box), while the box representing the second and third quartiles has also expanded somewhat, as was seen with the distributions of free SO_2. However, red wines do not illustrate the same widening of the distributions but rather a general downward shift in the entire distribution from 2016 onwards, with a reduction in the number of outliers at the upper end of the distribution from 2019 onwards.

The mean concentrations of bound SO_2 peaked at 101.4mg/L for white and rosé wines in 2010, and at 62.1mg/L for red wines in 2009. Godden *et al.* (2015) noted that declines in this measure appeared to have become established since those vintages, which is confirmed by the more recent data. The means of bound SO_2 for white/rosé wines and red wines have fallen to 80.3mg/L and 36.6mg/L, respectively, in 2021.

The distribution of mean bound SO_2 concentrations in white and rosé wines (Figure 5b) once again illustrates the recent cohort of low-intervention wines, which have negligible bound SO_2, and as with total SO_2, there is a widening of the distribution from 2012 onwards. Red wines, however, do not demonstrate the low-intervention cohort for bound SO_2 (Figure 6b, page 34), but do show the same narrowing of the distributions seen with total SO_2 in red wines, particularly with the first, and to a lesser extent with the second and third quartiles, but not with the fourth.

The ratio of free-to-total SO_2 provides some indication of a wine's history of microbial stability and/or oxygen exposure. Both of those factors lead to a loss of SO_2 in the free form, with a greater proportion of SO_2 becoming bound to other compounds in the wine, thereby reducing its anti-microbial and antioxidant

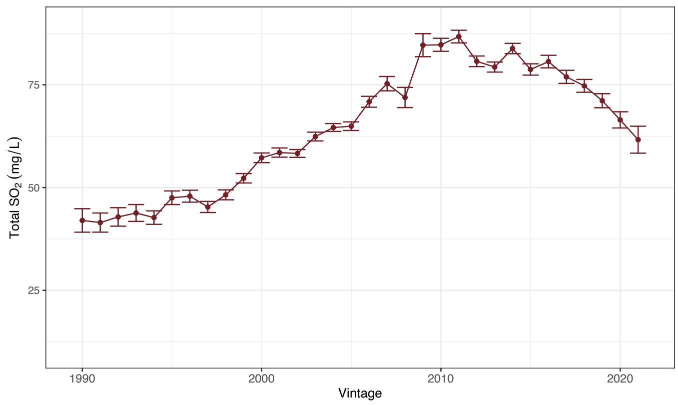

Figure 4a. Mean concentration of total SO_2 in red wines 1990-2021.

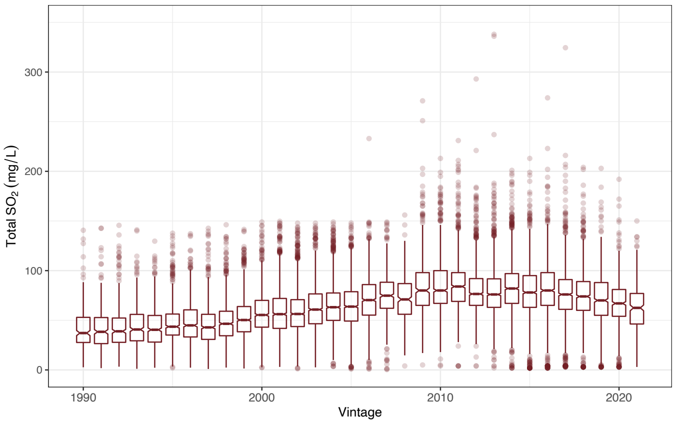

Figure 4b. Median (horizontal line) and distribution of total SO_2 concentrations in red wines 1990-2021.

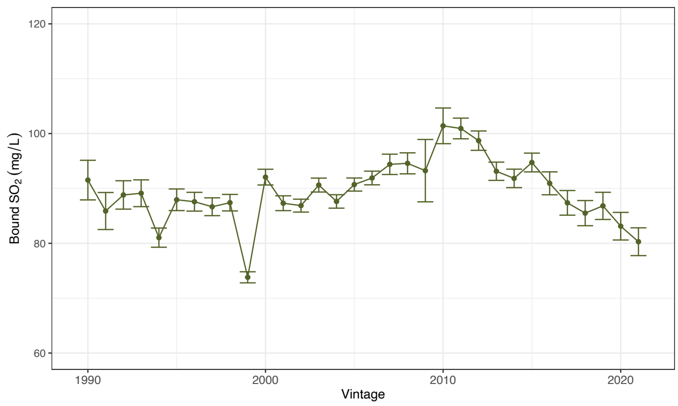

Figure 5a. Mean bound SO_2 concentration in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

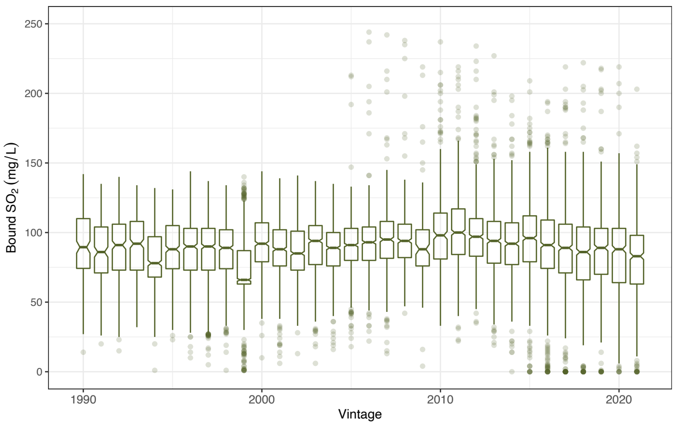

Figure 5b. Median (horizontal line) and distribution of bound SO_2 concentrations in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

properties. Strategies to increase the ratio of free-to-total SO_2 and how to use it in routine quality control and troubleshooting were advocated in AWRI workshops presented in many wine regions around Australia from 2001 onwards, and by Robinson and Godden (2003). It is therefore pleasing to note that the mean ratio of free-to-total SO_2 continued to increase to 0.28 in 2021 for white and rosé wines, and to 0.45 in 2021 for red wines (Figures 7a, page 35, and 8a, page 36). However, it should be noted that based on data published in 2015, the ratio of free to total SO_2 in red wines for the two most recent vintages are the compositional variables most likely to change over time as more data points for those vintages are added from the analysis of older wines. Nonetheless, the mean 2020 and 2021 ratios of 0.40 and 0.45, respectively, were accurate when the plots were generated, and are testament to excellent SO_2 management, enhancing the long-term stability of those wines in overseas markets.

The distributions of free-to-total SO_2 ratios (Figures 7b, page 35, and 8b, page 36) both highlight the low-intervention cohort; that is, wines that have negligible free and total SO_2, and, hence, a high ratio of free-to-total SO_2 of ~1.0. However, while the number of outliers at that level is visually striking on the plots, they represent a very small proportion of the overall data set and are not present in sufficient numbers to influence the overall trends.

Otherwise, the plots for the distribution of free-to-total SO_2 ratios for white/rosé wines and for red wines are more similar than for the other SO_2 measures, both demonstrating a general upward shift in the entire distributions since the 2015 publications, with that upward shift most evident in red wines (Figure 8b).

The strong upward trend in the ratio of free-to-total SO_2 in red wines indicates that, as with white and rosé wines, Australian winemakers are successfully employing strategies to make their SO_2 additions more effective. A contributing factor might be the widespread uptake of crossflow filtration in recent years. Many substances that might cause increased turbidity in wines can bind SO_2 (Robinson and Godden 2003), so the ability to achieve lower turbidity earlier in a wine's life might indirectly lead to less SO_2 becoming bound, and a consequent increase in the ratio of free-to-total SO_2.

As stated above, while the data presented here indicate excellent SO_2 management by Australian winemakers, it should also be noted that the actual free and total SO_2 concentrations at bottling have, in all probability, reduced to a point close to the

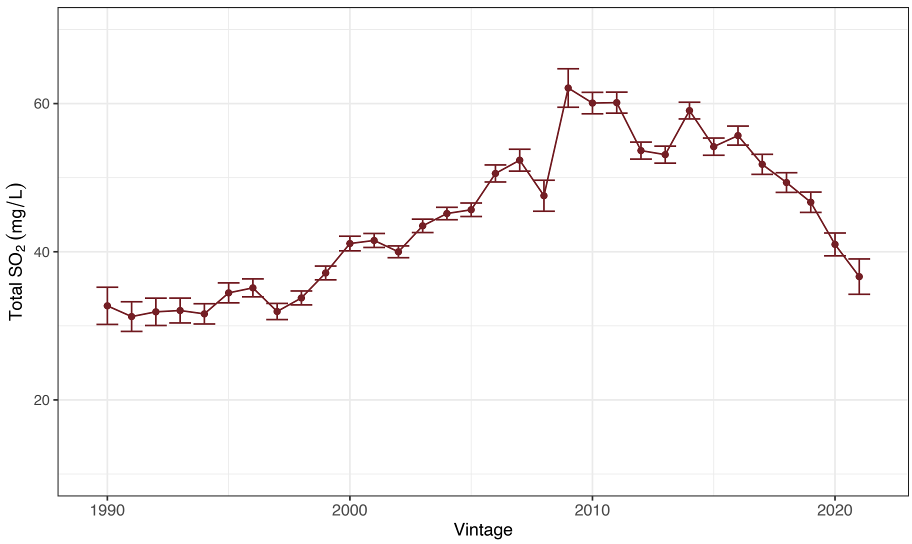

Figure 6a. Mean bound SO_2 concentration in red wines 1990-2021.

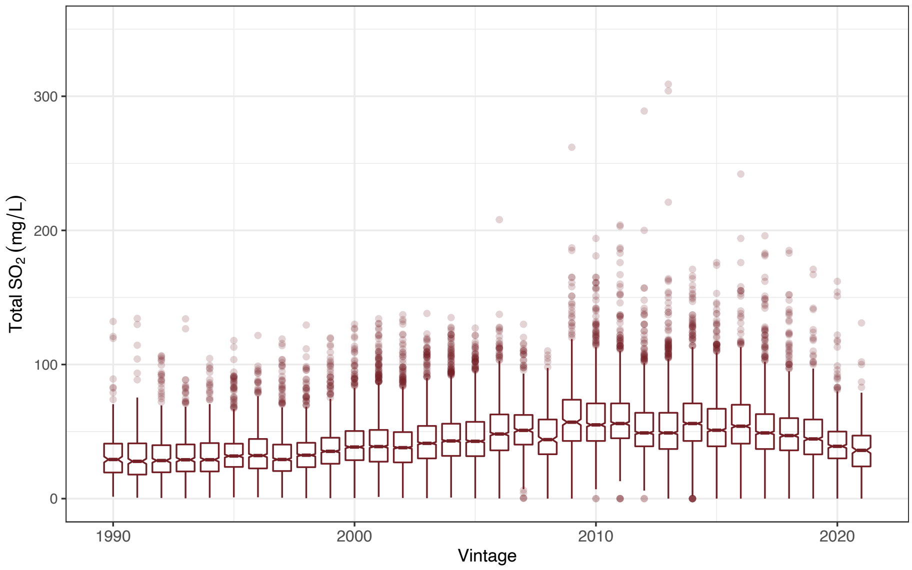

Figure 6b. Median (horizontal line) and distribution of bound SO_2 concentrations in red wines 1990-2021.

minimum concentrations recommended by the AWRI. Cowey and Coulter (2021) state that for white wines, free SO_2 at bottling should be 35-40mg/L for a two-year shelf life and 40-45mg/L for a five-year shelf life. For red wines, total SO_2 at bottling of 65-70mg/L is recommended for a two-year shelf life, 85-95mg/L for a three-year shelf life, and 95-105mg/L for a five-year shelf life. Therefore, that free SO_2 concentrations for white/rosé wines and for red wines seem to have stabilised at approximately 28mg/L and 25mg/L, respectively, might be seen as positive. However, further reductions in total SO_2 concentrations from the current 108mg/L for white and rosé wines, and 62mg/L for red wines, might be counterproductive and have the effect of reducing the shelf life of Australian wines in international markets.

CONCLUDING COMMENTS

The compositional data reviewed in this three-part series provides an overview of common analytical parameters of Australian wines being consumed internationally, with the extent and rate of change in composition being reflected. To the extent that market tastes over time are reflected, extrapolation may provide insights into future market demands, with potential economic benefit for wine producers who use the data to set objective specifications for future grape and wine production. The data might also be used by wine producers to benchmark the composition of their own wines for several key compositional variables against the overall trends for exported wines.

During the 38-year period for which data has been reviewed by publications in this series, the Australian wine industry has undergone huge development and change, with the geographic range of viticulture, the area under vine, and the range of grape varieties being grown all increasing markedly. The technology available to winemakers also continues to increase, allowing winemakers to explore novel wine style and winemaking philosophies, resulting in greater diversity for consumers. Consumer preferences for wine types and styles also constantly evolve, or shift to new wine types altogether,

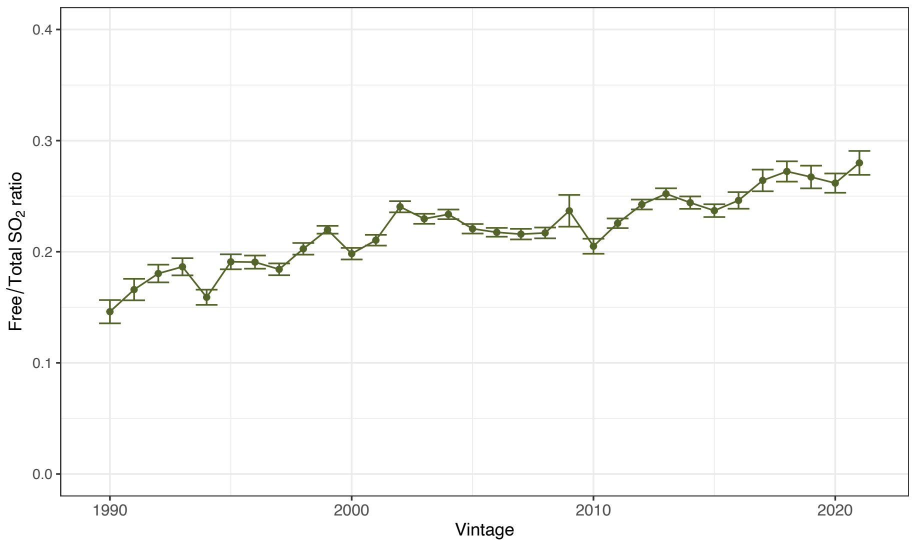

Figure 7a. Mean ratios of free to total SO_2 in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

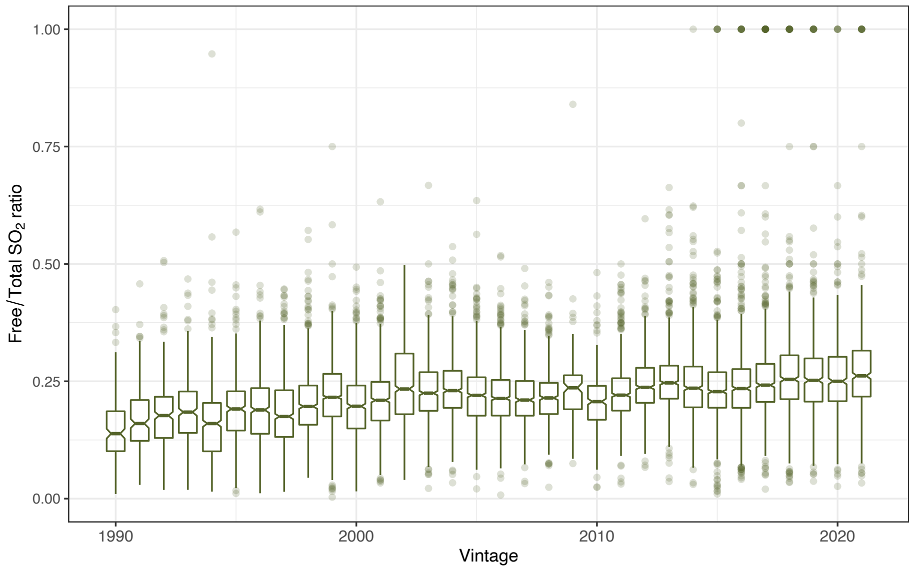

Figure 7b. Median (horizontal line) and distribution of ratios of free to total SO_2 in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

such as low-alcohol wines, the increasing numbers of rosé wines, and the recent rise in low-intervention wines. These trends are well reflected in the profile of wines being submitted to Affinity Labs and, consequently, in the data presented here.

In general, the trends captured present an insight into both the tastes of the market and Australian winemakers, because none should be considered solely market or production driven. In all probability, both the market and wine producers have a role in setting trends, but what does seem clear, as also noted in previous publications, is that once an upward or downward trend is evident, a large number of wine producers tend to follow it, sometimes resulting in the trend accelerating over time.

The last 10 years has also been a time of increasingly rapid climate change, in some vintages resulting in earlier harvest of grapes with sugar concentrations that are often higher than ideal, and the phenomenon of compressed vintages has also become a regular occurrence, where many grape varieties are ready for harvest at the same time. In compressed vintages, harvesting and winery processing capacity quickly reach their limit, resulting in grapes remaining in the vineyard for longer, with consequent additional sugar accumulation. Notwithstanding, data presented in this series of articles demonstrate downward trends in alcohol concentrations in white/rosé and red wines. This is likely driven, in part, by market preference as well as by the most notable change in winemaking regulation since the last publication in 2015 — the allowable addition of water to must to a sugar concentration of no less than 13.5 degrees Baumé.

It is likely that improved and more widely available winemaking technology also favours some of the identified trends, for instance, recent years have seen widespread uptake of crossflow filtration. This technology allows winemakers greater confidence that residual sugar and higher pH will not lead to later stability problems in bottled wine. Crossflow filtration also allows lower wine turbidity to be achieved at an earlier stage in the winemaking process, which probably contributes to the observed increases in free SO_2 and the ratio of free-to-total SO_2.

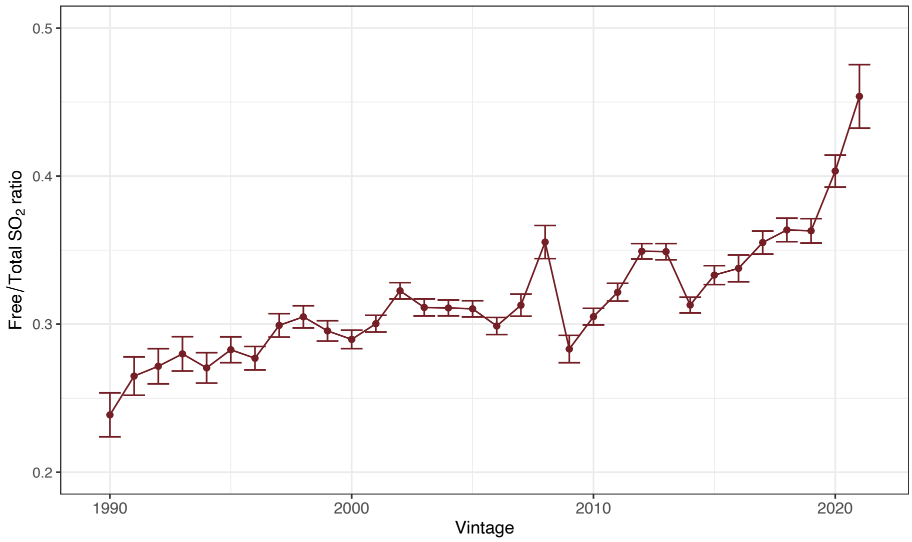

Figure 8a. Mean ratios of free to total SO_2 in red wines 1990-2021.

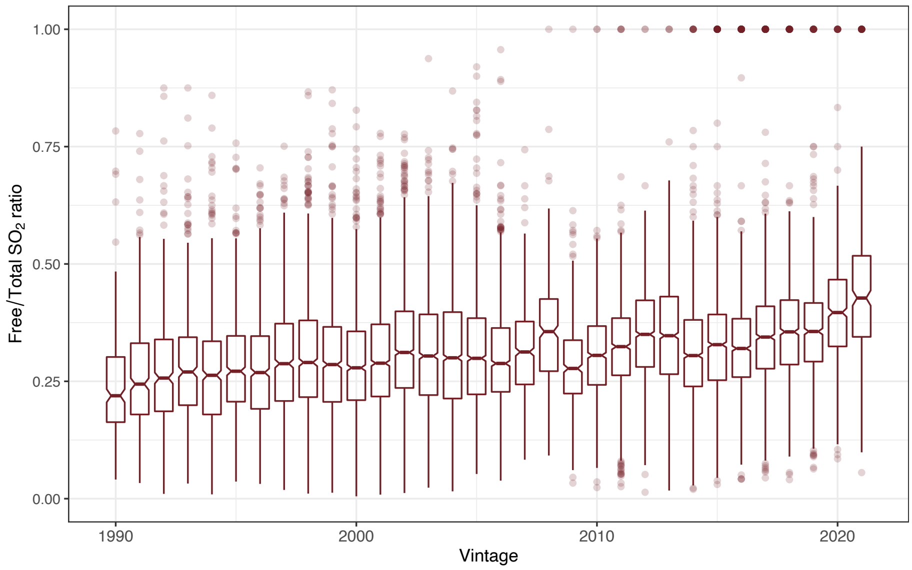

Figure 8b. Median (horizontal line) and distribution of ratios of free to total SO_2 in red wines 1990-2021.

Regardless of how the data presented in this series are used, the charts provide a graphic historical record of the composition of Australian wine for a 38-year period of extraordinary growth and technological change in the Australian wine industry and the evolution of Australia's wine offering over that period.

ACKNOWLEDGEMENTS

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