Trends in the composition of Australian wine 1990 to 2021

Part one: Introduction, titratable acidity and pH

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This article provides an update to previously published analyses of trends in Australian wine composition and is presented in three parts. Part one, published here, focusses on titratable acidity and pH. Part two will cover alcohol and glucose plus fructose concentrations, while part three will include free, total, and bound sulfur dioxide (SO_2) concentrations and the ratio of free to total SO_2, as well as overall concluding remarks. Parts two and three will be published in future issues of *Wine & Viticulture Journal*.

IN BRIEF

- Packaged wines are submitted for analyses to Affinity Labs, the commercial arm of the Australian Wine Research Institute, to ensure they comply with the import and export requirements of destination countries.
- Periodically, the data from these analyses are mined to examine the compositional trends in Australian wine.
- The focus of the latest examination was on titratable acidity, pH, alcohol, glucose plus fructose concentrations, free, total and bound sulfur dioxide concentrations, and the ratio of free to total SO_2.
- These latest analyses will be presented across three separate articles, with the first of these articles, presented here, focusing on titratable acidity and pH.

INTRODUCTION

Since its establishment in 1955, the Australian Wine Research Institute (AWRI) has accumulated a large body of knowledge on the composition of Australian wines. This includes a database of analytical results dating back to 1984, resulting from fee-for-service analyses of wine samples submitted to Affinity Labs (formerly AWRI Commercial Services, formerly the AWRI Analytical Service). That database represents a possibly unique resource in world terms and is periodically mined to examine compositional trends. Collated data have previously been published for mean alcohol concentration and mean SO_2 and volatile acidity concentrations (Godden 2000 and the 2003 and 2004 AWRI Annual Reports). In addition, Godden and Gishen (2005) presented data for an extensive range of compositional variables in white and red wines, including comparative data regarding Australian state and grape varietal trends, and that analysis was extended up to the 2008 vintage by Godden and Muhlack (2010). To mark the 60th anniversary of the foundation of the AWRI, Godden *et al.* (2015) extended the data series to wines from the 2014 vintage, and the current publication extends it further by adding data for the vintages 2015 to 2021.

Data for the vintages 1984 to 1989 (1984 to 1994 for glucose plus fructose), which have been discussed in previous publications, are not republished here. Primarily, this is to increase the clarity of the plots for the most recent vintages. It also recognises the comparatively low sample numbers and consequent higher levels of uncertainty in the data for those earlier years.

Consequently, data from the analysis of 85,448 wines are included here: 35,871 white and rosé wines (with rosé wines included from 2004 onwards) and 49,577 red wines. A total of 7212 white and rosé wines and 14,604 red

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wines from the most recent vintages were added to the data set reported by Godden *et al.* (2015). As with the 2015 publication, all additional data were generated from packaged wines which were submitted for analyses required to comply with the import and export requirements of destination countries. The new data includes multiple vintages of a broad cross section of Australian wines from commodity to icon status and producers of all sizes, with a wide geographical and varietal spread. Up to the 2003 vintage, the data includes both domestic and exported wines.

While representing a wide cross-section of wines from producers in all states of Australia, the sample of wines analysed cannot be considered perfectly representative of Australian commercial wine because it is a self-selected sample of wines submitted by clients of Affinity Labs and represents only exported wines from 2004 onwards. However, while Godden and Muhlack (2010) noted that the dataset was somewhat skewed towards higher priced wines and towards smaller sized wine producers, that appears to be increasingly less so over time. Data added for the 2015 paper and for the current publication includes an increasing proportion of commodity and entry-level wines from most of Australia's largest wine producers, as well as from third-party exporters. Therefore, due to the size and geographical spread of Affinity Labs' client base and the number of wines analysed, the data are considered in all probability to be strongly representative of trends in the composition of all Australian wine.

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, plotted as a line joining the means, together with vertical error bars to indicate the standard error for a 95% confidence interval. In the box plots, the centre horizontal line marks the median of the data for each year. The upper edge of the box represents the third quartile (below which 75% of the data resides), with the lower edge representing the first quartile (below which 25% of data resides), calculated according to the method of Tukey (1977). The 'whiskers' (the vertical lines extending above and below the box) show the range of observed values that fall within 1.5 IQR (Interquartile Range) beyond the box, where IQR is defined as the absolute value of the differences between the values of the two whiskers. Values beyond the whiskers (outliers) are shown as circles when they fall outside of 3.0 IQR beyond the box, with darker circles indicating overlapping results.

RESULTS AND DISCUSSION

The plots presented here summarise the analytical results recorded in the database when they were generated in mid-2022. New analytical results are continually added, especially for the most recent vintages and, consequently, some results for individual analytes presented here differ slightly from those in previous publications, without impacting the overall trends. That any such differences when additional data are added are so marginal, might reinforce the representative nature of the overall data set.

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. The proportion of rosé wines included in the data presented here for white and rosé wines is 8.13% compared to 7.08% in 2015. This represents a notable change in the nature of samples submitted for analysis compared to data presented in 2005 and 2010, from which the very few rosé wines which had been analysed at those time-points were removed, and reflects the dramatic growth in the rosé category internationally in recent years (Peres *et al.* 2020).

TITRATABLE ACIDITY

Titratable acidity at pH8.2 (TA) is a measure of all the acids that are present in the wine, chiefly tartaric, succinic, malic and lactic acids. TA is a good indicator of the amount of acid present in grapes as well as wine and is, therefore, often used to monitor the degree of ripeness of grapes, with TA decreasing with increasing ripeness. TA also affects the sensory properties of wine and, in some circumstances, might be used as a quality control measure to detect wine spoilage when volatile acids may be formed. TA can be adjusted by winemakers through the addition of allowable acids, which are purified from grapes, or by the addition of allowable mineral salts, such as potassium carbonate, which have the effect of reducing TA.

The mean and the distribution of TA concentrations in white and rosé wines remained largely stable between 1990 and 1995, and then again between 1996 and 2010, with no apparent effect from the inclusion of rosé wines from 2004 onwards (Figures 1a and 1b). However, from 2010 the mean values fluctuated markedly up until 2016, with a low of 6.25g/L in that year, followed by a steady increase to a high of 6.53g/L

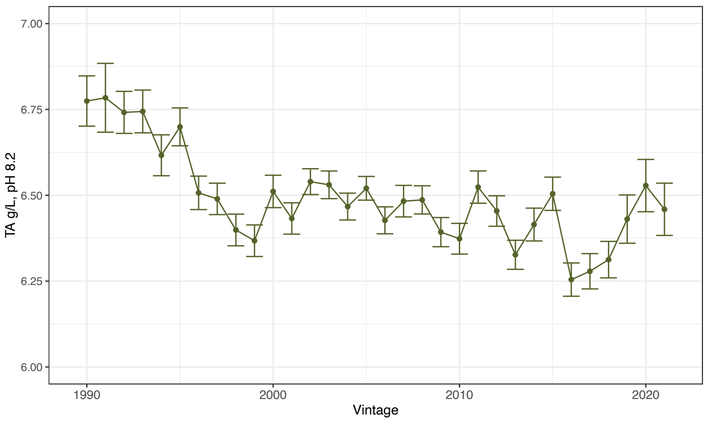

Figure 1a. Mean titratable acidity concentration at pH8.2 in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

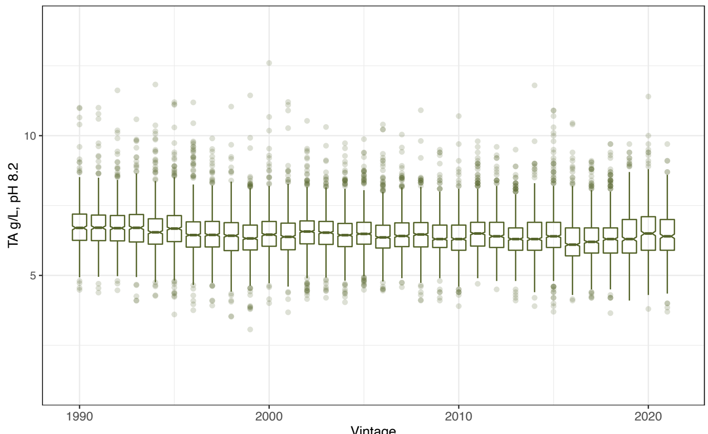

Figure 1b. Median (horizontal line) and distribution of titratable acidity concentrations at pH8.2 in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

in 2020, with corresponding shifts either upwards or downwards in the distribution of concentrations, but without marked changes in the makeup of those distributions. Comparison of the distributions of TA in rosé wines and white wines showed that the average TA was approximately 0.4g/L lower for rosé wines than white wines (data not shown). Previous papers in this series have stated that of all the compositional variables discussed, TA is the one over which the winemaker has the greatest control. However, that does not appear to explain such shifts in the distributions year to year, and it is possible that increasing climate variability is responsible for the comparatively high degree of variability seen since 2010.

If that were the case, similar year to year trends might also be expected with red wines. However, while year to year variability in TA concentrations has also increased markedly in red wines (Figure 2a), little relationship is seen between the trends for red wines and those for white and rosé wines. Of note is a marked above-trend increase of mean TA in red wines in 2018. That 2018 was a high TA year is confirmed by Cowey (2018), which indicated that during the 2018 vintage acid additions often resulted in a rise, instead of a decrease, in pH and a much higher TA than expected. This observation was attributed to markedly higher-than-usual potassium concentrations in fruit that year.

As demonstrated in Figure 2a, mean TA concentration in red wines increased steadily from 5.8g/L in 1990 to 6.49g/L in 2007, before a general downward trend became established. As with white and rosé wines, those upward and downward trends were mirrored by corresponding year-on-year shifts in the distribution of concentrations and were most likely winemaker driven according to the desired wine styles of the day. However, winemaking intervention seems unlikely to solely account for the substantial year-to-year variation seen on the downward trend since 2008. It is noted that while there is only an indirect relationship between TA and pH, no corresponding year-on-year variability is seen in the pH data presented in Figures 3 (a) and (b) and 4 (a) and (b). While it is not possible to state definitively the cause of the recent year-on-year variability in the formerly comparatively stable measure of TA, in the absence of other explanations, increasing year-on-year climate variability may be a contributing factor.

PH

The measure of pH is one of the most important analytical measurements in grapes and wine for several reasons. It provides a good indication of the degree of ripeness of grapes, has an important effect on the metabolism of microorganisms in wine and influences the flavour, colour, mouthfeel, and physical and microbial stability of wine. Lowering pH increases the proportion of sulfur dioxide (SO_2) in the 'free' form as opposed to the 'bound' form, and it is the free form which confers the greatest microbial and antioxidant ability (Boulton *et al.* 1996). Wine pH can be adjusted to some extent by winemakers through the addition of organic acids, such as tartaric acid to lower pH, or by the addition of

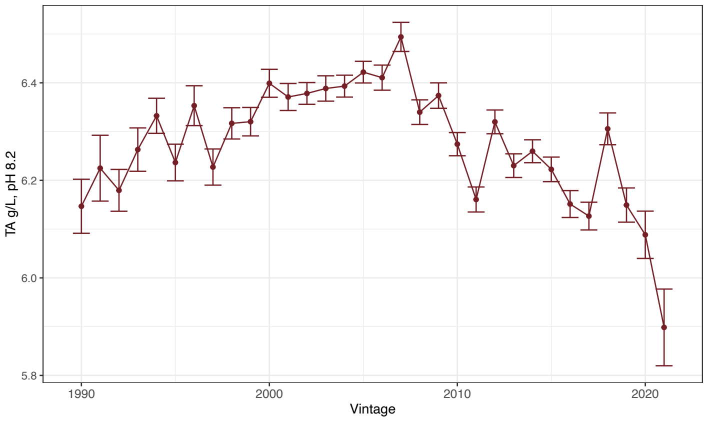

Figure 2a. Mean titratable acidity at pH8.2 concentration in red wines 1990-2021.

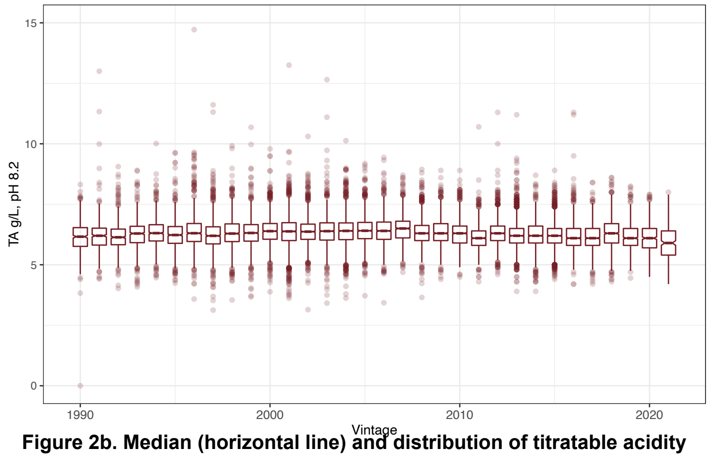

Figure 2b. Median (horizontal line) and distribution of titratable acidity concentrations at pH8.2 in red wines 1990-2021.

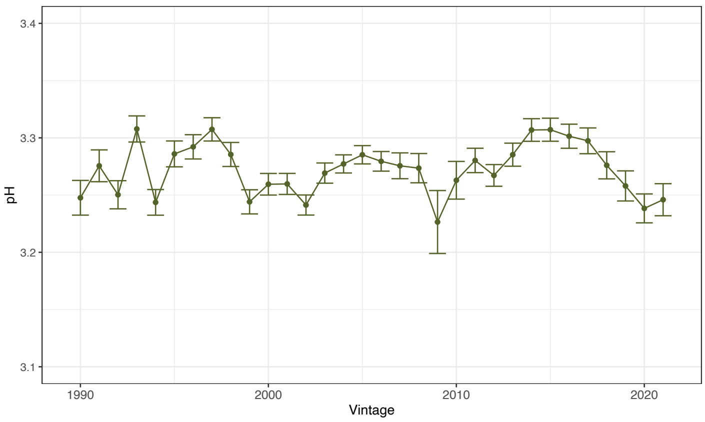

Figure 3 (a). Mean pH values in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

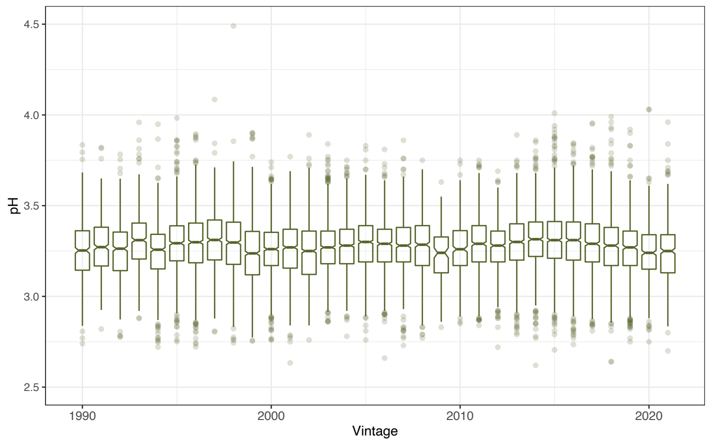

Figure 3 (b). Median (horizontal line) and distribution of pH values in white and rosé wines 1990-2021 (rosé wines included from 2004 vintage onwards).

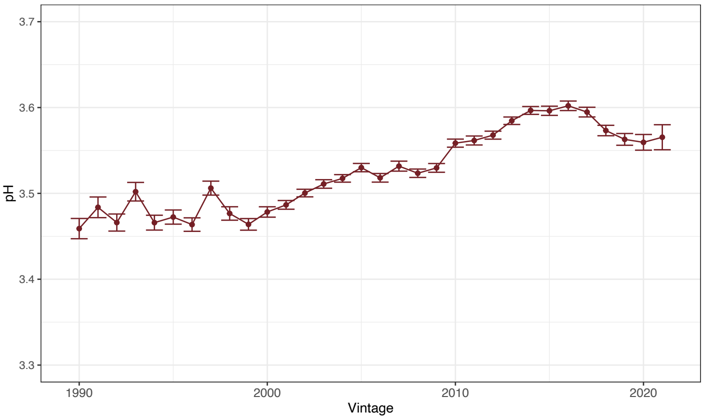

Figure 4 (a). Mean pH values in red wines 1990-2021

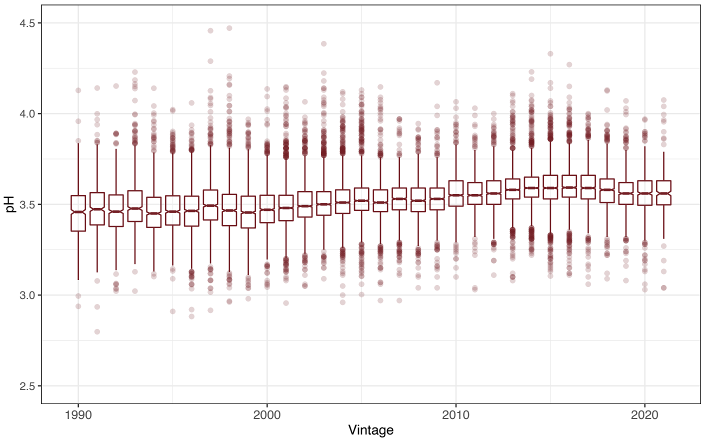

Figure 4 (b). Median (horizontal line) and distribution of pH values in red wines 1990-2021.

allowable mineral salts, which increase the pH.

Godden *et al*. (2015) noted an apparent trend of rising pH in the more recent vintages of white and rosé wines but found no statistically significant differences between the means. However, with increased sample numbers for those vintages, and the consequent reduction in statistical uncertainty, that upward trend to a peak pH of 3.31 in 2014 is now confirmed, but with a fall in subsequent years (Figure 3a). As with previous analyses, the markedly low pH in 2009 remains an outlier, probably due to the low sample numbers available for that vintage and the consequent large error. For this reason, that data point may probably be discounted. It should be noted that although upward and downward trends are apparent in the mean pH of white and rosé wines, with a slight upward shift in the distribution of pH values in rosé compared to white wines (data not shown), the quantum difference between vintages is small, with a difference of 0.08pH units covering the range for the averages in the entire data series between 1990 and 2021. As such, this is a stable measure, as illustrated by the distribution in Figure 3b, with only minor shifts up or down in the entire distribution year-on-year.

The story is different with red wines, with the steady upward trend in the mean pH continuing from that noted in the 2005, 2010 and 2015 publications, to a peak of 3.6 in 2016, with a downward trend becoming apparent in subsequent years. Likewise, the 2010 and 2015 papers in this series noted a marked narrowing of the distribution of pH concentrations up to the 2014 vintage, but that trend has also reversed since 2015, with a greater number of outlier wines at the lowest end of the distribution (Figure 4b).

The trend to higher pH in red wines seen from 1990 to 2016 probably reflects winemakers' choices, because higher pH results in wines which are 'softer' in the mouth, with higher perceived viscosity and lower perceived acidity (Gawel *et al.* 2014). However, at the same time, higher pH also increases the risk of wine instability, particularly microbial instability, largely through reducing the proportion of free SO_2. Therefore, Australian winemakers who are choosing to increase the pH of their wines should be aware of the increased associated risk of microbiological spoilage and oxidation, especially considering the downward trends of total SO_2 concentrations in both white and rosé wines and red wines, which will be presented in part 3 of this article.

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