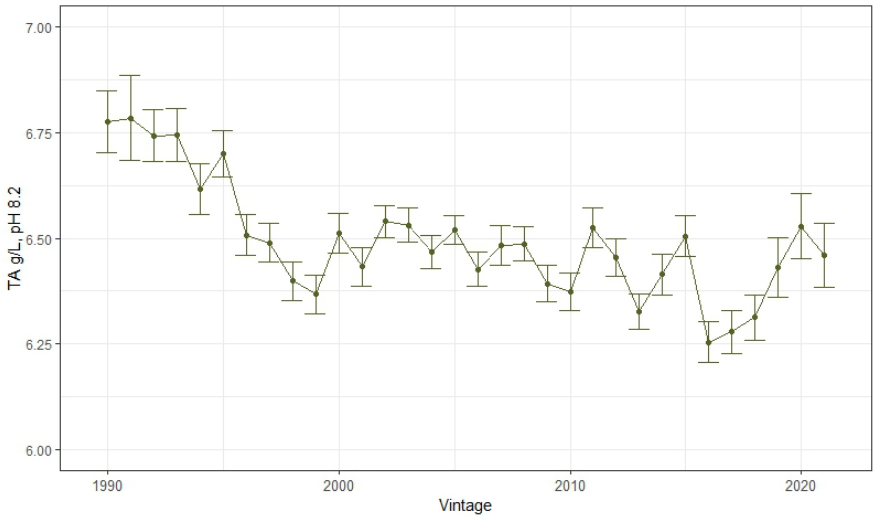
Australian Government
Wine Australia

AWRI Australian Wine Research Institute

Tracking trends in Australian wine composition and vineyard and winery practices



FINAL REPORT TO WINE AUSTRALIA

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Principal Investigator: Simon Nordestgaard and Eric Wilkes

Research Organisation: **Australian Wine Research Institute**

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Authors: Simon Nordestgaard and Eric Wilkes

Date: November 2022

Address: The Australian Wine Research Institute, Wine Innovation Central Building, Hartley Grove, cnr Paratoo Rd, Urrbrae (Adelaide), SA 5064

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1. Abstract

This project tracked trends in Australian wine composition and vineyard and winery practices. It developed a database of core compositional parameters and supported a survey of Australian viticultural and wine production practices. Targeted information was generated on trace metal content, lead concentrations in fortified wines, *Brettanomyces* spoilage markers, agrochemicals including iprodione and glyphosate, alcohol measurement, the vintage variability of alcohol by variety and the components contributing to the dietary energy content of wine. Two publications were produced, comprising a report on the AWRI Vineyard & Winery Practices Survey and a three-part article summarising trends in the composition of Australian wine from 1990 to 2021.

2. Executive summary

This project succeeding in providing robust and ongoing data to track trends in Australian wine composition and the vineyard and winery production practices used within the Australian grape and wine industry. The data generated are a valuable resource that will assist future planning of research and production activities and informed responses to government regulation, market access and research.

A regularly updated database of compositional parameters has been developed, to ensure that future research projects will have access to robust information from which to develop conclusions. This database will also act as a significant resource in discussions on future regulatory issues in export markets and help support national approaches to issues such as energy labelling.

The project supplied significant targeted data sets for a range of wine compositional parameters requested by peak wine bodies to address topical issues in domestic and export markets, including:

- the average trace metal content of Australian wine
- lead concentrations in table and fortified wines
- *Brettanomyces* spoilage markers
- iprodione and glyphosate in Australian wine
- the relative accuracy of alcohol measurement techniques
- the vintage-to-vintage variability of alcohol in certain varieties
- the contribution to dietary energy content of different wine components.

This information has been integral to the efforts of industry peak bodies and government when formulating responses to market trade issues and the development of national regulations. *Ad hoc* information on many other attributes of Australian wine was also provided on request to peak bodies as issues arose.

The two major publications arising from the project i.e. a report on the AWRI Vineyard & Winery Practices Survey and a three-part article on trends in the composition of Australian wine from 1990 to 2021, provide important benchmarks for future work and in-depth understanding of Australian wine and production processes. Eight articles, ten presentations and ten posters were also developed.

3. Acknowledgements

This work was supported by Australia's grapegrowers and winemakers through their investment body Wine Australia with matching funds from the Australian Government. The AWRI is a member of the Wine Innovation Cluster in Adelaide, SA.

The support of the Wine Australia regulatory and export licencing team in acquiring samples for many of the studies in this project is gratefully acknowledged. The support from Australian Grape and Wine, and its predecessor, the Winemakers' Federation of Australia in developing background information was also a significant aid for many of the studies.

The Interwinery Analysis Group provided significant data for the assessment of alcohol measurements and general support in developing an understanding of industry testing procedures.

The staff of Affinity Labs provided significant in-kind contributions to many of the studies in this project and their time and dedication are also acknowledged.

4. Background

This project contributed to the following broad aims:

- The availability of a consistent and robust dataset of the compositional trends of Australian wine.
- Knowledge on emerging production and technical trends in Australian grape and wine production.
- Levels of understanding and adoption of R&D outcomes are regularly measured and supported.
- Compliance with the Food Standards Code is demonstrated through analysis of a representative and comprehensive sample of Australian wines.

It tracked trends in Australian wine composition and vineyard and winery practices. Compositional trends were monitored by collating analytical data from wines submitted to the AWRI's commercial analytical laboratories, comprising an existing set of more than 25,000 samples annually. Where necessary, that data set was augmented with supplementary samples and analyses to address identified knowledge gaps arising from topical issues within both domestic and international markets. Examples of these included specific metals in wine, glycerol content and its impact on energy labelling, impacts on labelling information of analytical methodologies and the typical levels of certain pesticides relevant to international markets.

The practices information generated through the 2016 AWRI Practices Survey and associated commentary were collated in a report that was distributed via the AWRI website and promoted via a range of extension mechanisms including webinars, roadshows and presentations in other industry forums. The compositional information that complements the practices survey also featured in AWRI extension activities and provided additional context to information generated by other sources, such as vintage trends identified by the AWRI helpdesk. In addition, the data generated through this project were published in a number of industry journal articles (see Appendix 1).

In July 2022 a reference group including representatives from Wine Australia (Jo Hargreaves) and Australian Grape & Wine (Anna Hooper) was convened to provide input into questions for the second edition of the AWRI Vineyard & Winery Practices Survey. This survey was conducted in September and October 2022, with results to be published in 2023.

5. Project aims

This project aimed to deliver:

- A curated database of wine compositional data primarily consisting of analytical data generated by the AWRI's fee-for-service analytical laboratories.
- A report summarising vintage compositional information, likely to focus upon specific parameters of interest from year to year.
- A report summarising and interpreting the compositional and production practices information gathered, tailored for industry and academic journals (five-yearly, commencing in 2017).
- Further general and targeted presentations delivered via existing extension mechanisms

6. Methods

The approach taken for the project was to use a combination of data from the Affinity Labs (formerly AWRI Commercial Services) analytical results database, information from the Wine Australia Export database, targeted analytical surveys and industry questionnaires to develop an ongoing understanding of the composition of Australian wine and the vineyard and winery practices used to produce them. Further targeted information was developed as required by industry peak bodies (Wine Australia and Australian Grape & Wine), generally in support of the Market Access project (described in the Final Report for that project) and as directed by the Market Access Group. The latter data were given priority over other activities in the project as it was often required quickly to meet market access issues as they arose.

The Affinity Labs database has extensive information on a wide range of analytical parameters measured in wine. The data have been used previously to publish reports on the trends in a number of core analytes from 1984 to 2015 (Godden et al. 2005, Godden et al. 2010 and Godden et al. 2015).

To track wine composition, the project produced and managed a curated database (extracted from the Affinity Labs database) of core analytes (alcohol, free and total sulfur dioxide, glucose + fructose, pH and titratable acidity). This database also contains information on several other wine analytes including acetic acid and the metals potassium, sodium, calcium, copper and iron. The data have been selected to only include wines submitted for export certificates to ensure that they only represent finished wines and not those that may be at an intermediate stage of production (as this might otherwise skew compositional trends). The database also holds regional and varietal information for a significant number of wines from 2015 onwards; however, this is dependent on the information having been submitted by the client when the analysis was requested.

In cases where required compositional data were not available for a targeted analyte, samples were generally acquired with the support of the Wine Australia regulatory team or by direct appeal to industry, as was the case for the survey of glycerol content in no- and low-alcohol products.

The AWRI Vineyard & Winery Practices Survey was performed in 2016, before the commencement of this investment agreement. To validate and provide context to the data before publishing a report, follow-up visits, emails and phone calls were made to more than 100 respondents in 2017 and 2018. Meetings were also held with many major suppliers of vineyard and winery equipment and additives to further cross-validate data. Data representativeness was also validated by comparison with grape variety and yield information from the Australian Bureau of Statistics and Wine Australia.

7. Results and discussion

7.1 General wine compositional data

A major review of the compositional data was completed. The data were collated, interpreted and summarised for publication in the *Wine and Viticulture Journal*. The article 'Trends in the composition of Australian wine 1990-2021', will be published in three parts starting with the summer 2023 edition. Data from the analysis of 85,448 wines are included: 35,871 white and rosé wines (with rosé wines included from 2004 onwards) and 49,577 red wines. A total of 7,212 white and rosé wines and 14,604 red 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 that were submitted for analyses to comply with the export/import 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. The articles discuss the evolving trends in pH and TA (part 1), alcohol and glucose plus fructose (part 2) and free and total SO_2 (part 3).

To maximise the availability of the compositional data held in the database, processes have been put in place to automatically update the database on a six-monthly basis. Information will be available on an aggregated basis on request from stakeholders and will form the basis of a regularly updated information board on the AWRI website, with the new pages to be commissioned in early 2023.

7.1.1 Additional SO_2 data

One minor weakness of the Affinity Labs database is that there is no information on the packaging date for the wines, which means that the SO_2 as measured can be considerably lower than that at the time of packaging. To partially address this, it was decided to also investigate data from the Wine Australia export licencing system to assess typical SO_2 levels. Data for this system are typically submitted from the analysis conducted on wines at the time of bottling and as such are likely to provide a more consistent indication of typical levels. Data were analysed for more than 3,000 wines from the 2016 and 2017 vintages and the results were reported in an *AWRI Technical Review* article (Wilkes 2018a). Essentially the data demonstrated good alignment with results collated for the previous compositional trends paper (Godden et al. 2015). Both red and white wines were found to be packaged at a mean free SO_2 of ~31 mg/L with a standard deviation of between 9 and 10 mg/L (Table 1). There was no significant difference between the two vintages and no major difference in free SO_2 levels between the major varieties. These figures are slightly higher (~4 to 5 mg/L) than those found in the Affinity Labs data, demonstrating the impact of package oxygen immediately post-packaging. While the general trends correlate, increasing the confidence in conclusions drawn from the Affinity Labs dataset, there is an apparent need to regularly interrogate this independent data source for this analyte.

Table 1. Statistical summary of SO_2 data from Wine Australia's export licence database for the 2017 and 2017 vintages. All SO_2 results are in mg/L.

All wines		**Mean**	**Standard deviation**	**Number of samples**	**Minimum value**	**1st Qu**	**Median**	**3rd Qu**	**Maximum value**
	Free SO_2	30.6	9.8	3,167	0	27	32	37	126
	Total SO_2	93.7	34.8	3,167	0	72	92	117	233
Red									
	Free SO_2	30.5	9.5	2119	0	27	32	36	89

	Total SO_2	83.8	30.2	2119	0	66	82	101	219
White									
	Free SO_2	31.0	10.4	1048	0	26	32	37	126
	Total SO_2	113.9	34.6	1048	0	98	116	134	233
2016									
	Free SO_2	30.4	9.6	2278	0	27	32	36	126
	Total SO_2	94.0	34.2	2278	0	73	92	115	233
2017									
	Free SO_2	31.1	10.3	889	0	27	32	37	61
	Total SO_2	93.0	36.2	889	0	70	93	118	221

As expected, there were significant differences between red and white wines for total SO_2 levels (see Table 1 and Figure 1). The mean value for red wines and white wines was 83.8 mg/L and 113.9 mg/L respectively, with a statistically insignificant variation between vintages. The analysis did show some differences between the varieties for total SO_2, particularly for the white wines. Importantly, none of the data demonstrated any wines exceeding international regulatory limits.

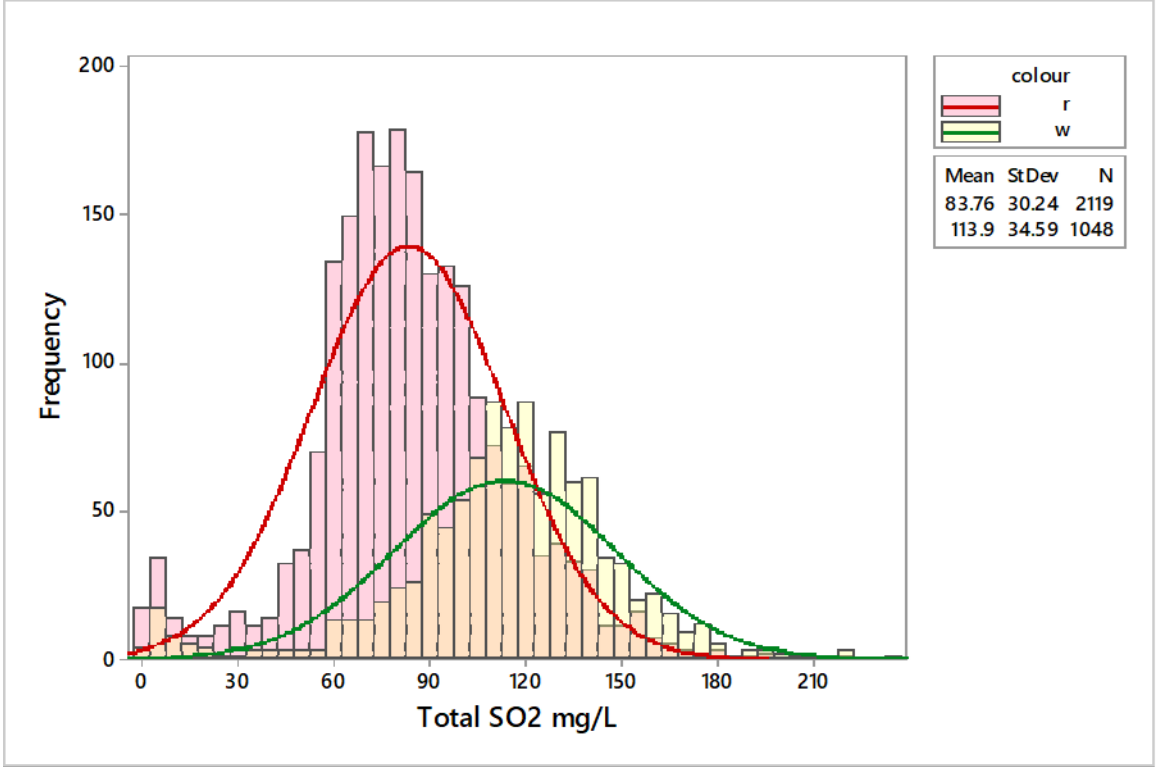


Figure 1. Distribution of total SO_2 values (mg/L) for red and white wines. Data sourced from Wine Australia's export licence database for the 2016 and 2017 vintages.

7.1.2 Time-series collection

An additional planned activity was to establish a time-series collection of ten benchmark Australian wines by approaching producers to provide two cases of wine annually and then to analyse them for a range of standard analytes. Unfortunately, it was not possible to secure this commitment from sufficient producers and this trial had to be abandoned. Nonetheless, reviews of the compositional database demonstrated that most commercial wines were well represented in the dataset from 2015 onwards and the data already available provided sufficient information to be able to determine the vintage to vintage impacts on compositional parameters.

7.2 Targeted analysis and reports

During the investment period, a number of targeted surveys were carried out at the request of industry peak bodies for specific sets of analytes or data to demonstrate the impacts of wine processes. An overview of each study is provided below, with references to the relevant publication.

7.2.1 Metals in Australian wine

The concentration of different metals in beverages such as wine have regularly been raised in the press as a matter of concern in a number of markets as well being reviewed by regulatory bodies in numerous economies. This has led to regular requests for information on the metals content of Australian wines from WITAC and Wine Australia. To support this, a baseline data set of wine metals content was collated and periodic reviews of this data will be conducted.

Aggregated data from more than 1,200 wines analysed from October 2016 to September 2017 were used to assess the metal content of Australian wines and provide a benchmark for future studies. The samples included only finished commercially produced wines, 55% red and 45% white, with sparkling and fortified wines excluded. Metals were analysed using inductively coupled plasma mass spectrometry. The specific elements examined included aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), manganese (Mn), nickel (Ni), palladium (Pd), platinum (Pt), selenium (Se), silver (Ag), strontium (Sr), tin (Sn), vanadium (V) and zinc (Zn). Potassium (K), sodium (Na), calcium (Ca) and magnesium (Mg) were also measured – these are typically found in wine at higher concentrations than the other metals listed. The results of the study were published in *AWRI Technical Review* (Wilkes 2018b), and a summary is provided in Table 2.

The survey confirmed that all wines analysed met international limits for metal content.

A comparison of these data was also made with a new data set from 2019 and no significant changes in mean values were noted.

Table 2. Trace metals concentrations found in a range of red and white wines. All results are presented in ppb. Values marked with a * are at the limit of detection (LOD) for the analytical method

	Wine	Number of samples	Mean	Standard deviation	Minimum value	Median	Maximum value
Aluminium	red	703	302.7	269.7	17	215	2330.6
	white	570	697.6	595.7	5	531	4909
Arsenic	red	703	2.4427	2.3617	1*	2	20.2
	white	571	3.799	3.576	1*	3.1	33.8
Cadmium	red	703	1.0357	0.2816	1*	1	3.7
	white	571	1.0322	0.3431	1*	1	6.5
Chromium	red	703	13.361	6.555	1*	13	73
	white	570	9.691	7.411	1*	8.1	67
Cobalt	red	703	4.461	2.997	1*	3.9	32.9
	white	570	3.464	2.3378	1*	3.3	21.9
Copper	red	705	266.2	312.5	50*	200	4100
	white	577	338.6	893.6	50*	100	9500
Iron	red	705	1657.1	852.5	150*	1500	7520
	white	576	950.3	1055.5	150*	700	12400
Lead	red	703	3.926	8.188	1*	2.6	154.1
	white	571	12.66	24.12	1*	8.7	263.8
Lithium	red	703	10.533	7.506	2.5*	8.8	59.6
	white	570	8.896	6.095	2.5*	8.3	32.5
Manganese	red	705	144.66	641.5	150*	1300	5700
	white	577	960.8	640	150*	900	8100
Nickel	red	703	14.346	12.976	1*	12.8	311.3
	white	569	13.843	11.921	1*	11.4	95.7
Palladium	red	703	1.4211	1.4092	1*	1	17.9
	white	571	1.5794	1.666	1*	1	15.1
Platinum	red	703	1.0043	0.0652	1*	1	2
	white	571	1.0018	0.0418	1*	1	2
Selenium	red	703	1.7913	2.402	1*	1	27
	white	570	1.541	0.3011	1*	1	21.1
Silver	red	697	1.0363	0.0419	1*	1	5.0
	white	569	1.0018	2.3357	1*	1	2.0
Strontium	red	703	1565.4	680.9	118	1468	4717
	white	571	830.1	602	1*	680	3754
Tin	red	703	2.847	3.036	1*	2	30.5
	white	570	4.587	11.868	1*	2.55	200
Vanadium	red	703	4.77	10.936	1*	1	84.9
	white	570	4.833	10.969	1*	1	135.4
Zinc	red	703	993.7	435.9	35	979	4089.9
	white	571	782.7	598.5	2.5*	731.4	9333

7.2.2 Lead in wine

A potential issue was identified by Australian Grape & Wine and Wine Australia when a new limit for lead content in wines was proposed by the Codex Commission and a review of permitted lead content in wine put in place by the OIV. While data from the previous study of metals in Australian wines gave confidence that the typical levels of lead in table wines were well below the proposed 50 ppm limit, there was considerable concern that fortified wines might exceed this value on occasion. Higher metals concentrations in fortified wines are a natural consequence of the ageing and concentration processes used in their production, but this still does not represent a danger to health.

Based on concerns about this potential change, 20 fortified wine samples were sourced from Australian suppliers by Wine Australia and analysed at the AWRI for their lead content. This study found that the mean concentration of lead in the fortified wines analysed was 64 ppm and a significant number of samples exceeded the proposed limit. The data generated were used by Wine Australia and Australian Government representatives in their submission to both Codex and the OIV. As a result of this, and lobbying by other economies, a separate higher limit for fortified wines was accepted by both bodies – an excellent result for Australian fortified wine producers.

7.2.3 *Brettanomyces* spoilage markers

In conjunction with the AWRI helpdesk project and the Wine Australia-funded research project on *Brettanomyces,* a survey of *Brettanomyces* spoilage compounds in wine was reinitiated to supplement data collected in the early 2000s. The update to the survey measured 4-ethyl phenol (4EP) in 91 wines from the 2015 vintage. The mean concentration of 4EP in the 2015 wines tested was just 29 µg/L, lower than concentrations reported at the end of the previous survey in 2005. The highest 4EP observed was 327 µg/L, which is below the sensory aroma threshold. Approximately 60% of the Australian wines tested contained 'not detectable' levels of 4EP. No viable *Brettanomyces* yeasts were isolated from any of the wines. These results suggested that the increased helpdesk enquiries regarding *Brettanomyces* were not correlated with a higher mean 4EP concentration in bottled Australian wine. The full results of this survey and their general implications were reported in the AWRI's 2018 Annual Report and the 2022 Final Report for Project 2.2.1 – AWRI helpdesk.

7.2.4 Iprodione

Iprodione is an agrochemical used for the control of *Botrytis* bunch rot in grapes. However, in 2019, some of Australia's export markets changed their MRLs for iprodione, essentially banning the import of wines showing any detectable levels of iprodione residues. A review of iprodione levels found in wine for the 2017 and 2018 vintages was carried out to in response to this change. The data were collected from 704 wines submitted to AWRI Commercial Services for a standard agrochemical residue screen. The study demonstrated that that 80% of 2017 wines and 91% 2018 wines fell below the limit of quantitation for iprodione. However, this still represented a significant risk for producers. The study also demonstrated the persistence of the residue in wine and the importance of requiring that any limitation imposed by export markets allow for wines produced before the ban. The data from this study were provided directly to Wine Australia and Australian Grape & Wine and not published.

7.2.5 Glyphosate in wine

As a result of perceived issues of high glyphosate levels in US beverages and changes in regulations on the use of this herbicide in Europe, a review of glyphosate concentrations in 100 Australian wines was carried out, in conjunction with a Wine Australia survey. The review found that 20 out of the 100 wines had detectable levels of glyphosate above the limit of quantification. All results were, however, well below the Australian MRL for this substance. Data from this review were provided directly to Wine Australia and not published.

7.2.6 Alcohol measurement in the Australian wine industry

As part of a submission by Australian Grape & Wine and Wine Australia to the UK government on new proposed excise arrangements for alcoholic beverages, it was decided that an understanding of the relative accuracy of the different analytical techniques in play would be useful. To achieve this, a review of two years of results from the Interwinery Analysis Group (IWAG) ring test program was undertaken. The data included 12 rounds of testing with each laboratory testing two samples of the same wine in each round. On average, 162 facilities submitted results in each testing round. Obvious outliers were removed, as were methods used by only two to three laboratories, leaving 3,838 submitted values. Each round of testing was then normalised to an average alcohol value of 12.5% v/v and the combined results were used to compare the different methods. The study, published in *AWRI Technical Review* (Wilkes and Pride 2022), clearly demonstrated that NIR techniques dominated laboratories in Australian facilities, representing 69% of measurements, with FTIR-MIR being the next most common at 19%. Interestingly this methodology was also the most accurate, with a standard deviation of only 0.08% on a normalised 12.5% v/v alcohol. Older techniques such as distillation-hydrometry and ebulliometry had standard deviations 2.5 to 3 times larger. A visual representation of this comparison is presented in Figure 2.

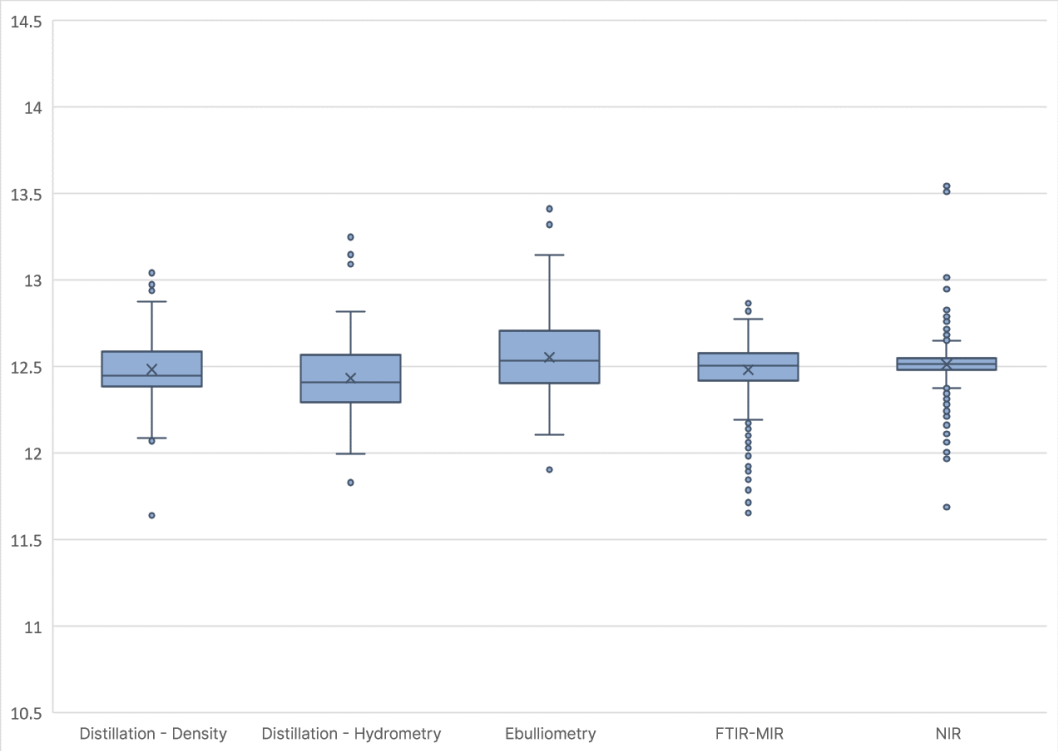


Figure 2. The relative spread of results from five different analytical methods for alcohol in wine, as measured by laboratories in the Interwinery Analysis Group, with each round of testing normalised to an average value of 12.5% (v/v). The boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value and the cross representing the mean. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers (which are shown as blue circles).

7.2.7 Vintage to vintage variability of varietal alcohol

A supplemental part of this study (not published but important for the submission to the UK government) was an understanding of the vintage-to-vintage variation seen for alcohol for different varieties of Australian wine. as this could affect the shelf price of wines under the proposed excise system. Using data covering the 2012 to 2020 vintages from the Affinity Labs database, it could be seen that there were significant variations in median alcohol for some varieties between vintages (Figure 3). These variations would be enough to see some wines move between excise brackets on a year-to-year basis, potentially leading to large shelf price variations. This would be the case, for example, for Sauvignon Blanc (Figure 3). These data were

passed directly to Wine Australia and not published, but this work did, with further supplemental information, provide the basis for a poster presented at the 18th Australian Wine Industry Technical Conference in June 2022 (Wilkes 2022).

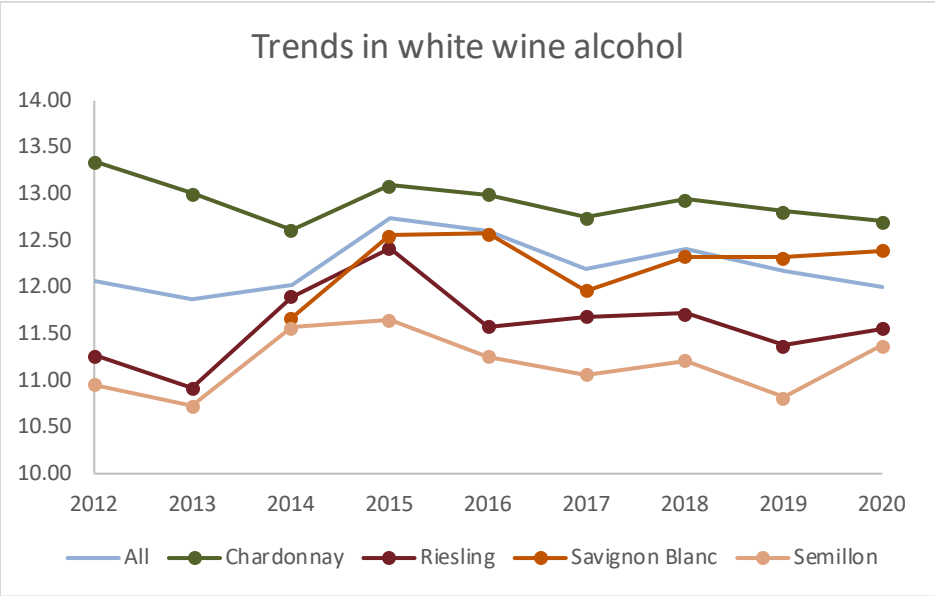


Figure 3. Trends in the alcohol concentration in Australian white wines, combined (light blue) and separated by variety

7.2.8 The contribution of different components to the energy content of wine

There is increasing demand from both consumers and regulatory bodies to include information about the dietary energy content of wines either on wine labels or at an easily accessible location such as a linked website. Provision of this information requires a uniform method of measuring energy content to ensure that the information provided to consumers is useful, consistent and accurate. As is the case for most foods and beverages, it is not practical to measure the energy content of a specific wine product directly. Instead, the usual approach is to calculate the sum of contributions of individual components using published values for energy. Although in wine most of the dietary energy content comes from alcohol, it was determined that more information was needed on the proportional contribution of other wine components, especially in light of the increasing importance of no- and low-alcohol (NOLO) products.

An important part of this was an understanding of the typical levels of glycerol in both wines with typical alcohol concentrations and in NOLO products. Literature values tended to vary considerably, with little published on Australian wines and nothing available on NOLO products. To address this knowledge gap, 60 commercial wines and 30 NOLO products were sourced and their glycerol levels determined by Affinity Labs' standard analytical methods. The results showed mean glycerol contents of 5.4 g/L (standard deviation 1.1 g/L) for white wines and 9.6 g/L (standard deviation 1.2 g/L) for red wines. For the NOLO products a similar distribution of glycerol concentrations to white wine was evident (Figure 4).

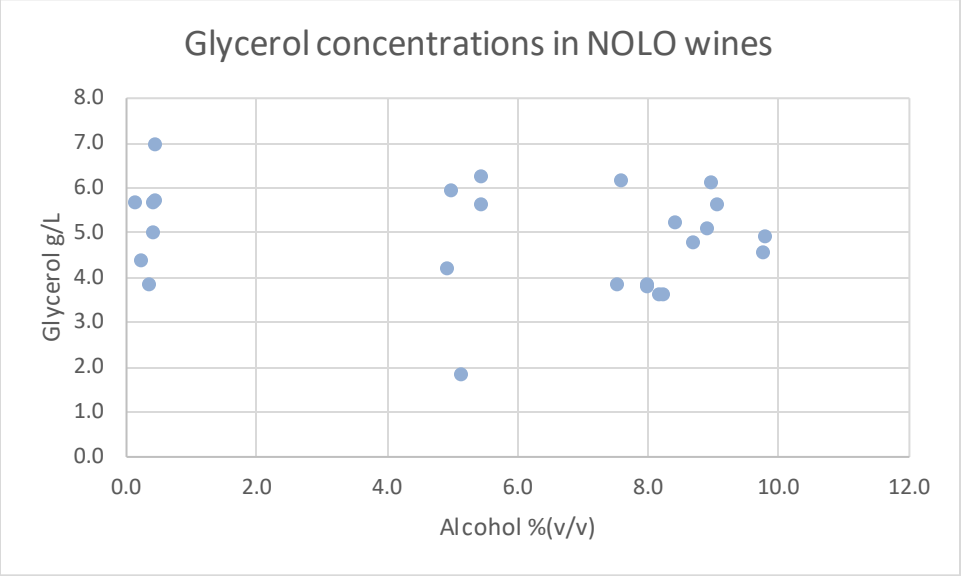


Figure 4. The glycerol concentrations measured in a range of reduced-, low- and no-alcohol wine products

The glycerol data were combined with compositional data from around 10,000 wines covering the 2016-2020 vintages from the curated database described in Section 7.1. The combined data were assessed to understand the likely variability in energy content based on the typical variation in composition seen in Australian wines, with the full analysis published in the *AWRI Technical Review* (Wilkes 2021a). Key recommendations arising from this work were:

- Energy content calculations for table wines and NOLO wines should be made using measured values for alcohol and sugar and set values for glycerol and titratable acidity (as a proxy for organic acids).
- The set values for glycerol and titratable acidity for red and white wines could be defined by their median values determined from the AWRI wine survey.
- Other wine components and additives can be generally ignored as not contributing significantly to the energy content.
- The validity of these assumptions should be reviewed every ten years by reference to survey data to ensure that the introduction of new technologies or additives has not significantly changed the typical values.
- The energy density figures used for the calculation of energy values for the label wines and wine products in Australia should be those published by FSANZ

This work was further extended as part of the AWRI's market access project, where it was demonstrated that using these values and the 20% label tolerances commonly adopted in Australia's major export markets that wines could labelled with generic energy contents based on wine style (Wilkes 2021b).

7.3 AWRI Vineyard and Winery Practices Survey

In late 2016, the AWRI performed a large survey (691 responses) of Australian vineyard and winery practices. During the investment period the data from the survey were analysed and more than 100 of the respondents were contacted individually to 'ground truth' their responses. The full report detailing results from the survey was released in 2019 and is available for download from the AWRI website (Nordestgaard 2019, Figure 5). The report presents information on the fundamentals of grape and wine production in Australia as well as on the adoption of new technologies across different operational sizes and vineyard regions. It

illustrates that while some technologies have been widely adopted (e.g. cross flow filtration for wine clarification), others so far have not (e.g. sensors to monitor ferment progress).



Figure 5. AWRI Vineyard and Winery Practices Survey (Available for download from www.awri.com.au/survey)

A presentation of the survey results was made to the 2017 ASVO Viticulture seminar, where it formed the basis for a panel discussion on topics including the use of destemming harvesters, recycle sprayers and precision viticulture. Presentations were also made to the 2017 Crush Symposium, to the 2018 Winery Engineering Association conference and as part of regional tasting sessions on red wine production techniques.

In July 2022 a reference group was convened to provide input into questions for the second edition of the AWRI Vineyard & Winery Practices Survey. This survey was conducted in September and October 2022, with results to be published in 2023.

8. Outcome and conclusion

Overall, this project achieved it goals by providing robust and relevant data on both wine compositional trends and the vineyard and winery production practices of the Australian grape and wine industry. These are valuable resources which allow for future planning for both research and production activities and informed responses to government regulation, market access and research. The availability of a regularly updated database of compositional parameters will ensure that future research will have access to robust information from which to develop conclusions. It will also provide important benchmarking information for discussions on future regulatory issues in export markets and defining national approaches to issues such as energy labelling.

The project also supplied significant targeted information on wine composition aspects, including average trace metal content, lead in table and fortified wine, *Brettanomyces* spoilage markers, iprodione, glyphosate, alcohol measurement techniques, the vintage-to-vintage variability of alcohol in certain wine varieties, and the contribution of different components to overall dietary energy content of wine. This information has been important in supporting industry peak bodies and government in the formulation of responses to market trade issues and the development of national regulation.

The two main publications to come out of the project, the report on the AWRI Vineyard & Winery Practices Survey and a three-part article on trends in the composition of Australian

wine from 1990 to 2021, provide important benchmarks for future work and in-depth understanding of Australian wine and production processes.

9. Recommendations

The availability of accurate information on wine composition and production practices is critical for informed responses to government regulation, supporting market access and as a basis for relevant research and development projects. For these reasons it is recommended that resources be allocated to allow this work to continue to provide information on long-term trends and to allow the agile provision of data to ensure the success of the Australian wine industry.

10.Appendix 1: Communication

Presentations

- S. Nordestgaard, Technology adoption in viticulture – how many people are doing what?, ASVO Seminar, Mildura, Vic., 2 July 2017
- S. Nordestgaard, Trends in Australian winemaking practice, Crush 2017 – the grape and wine science symposium, Adelaide, SA, 14 November 2017
- S. Nordestgaard, Trends in wine production technology and future challenges, Winery Engineering Association Conference, Nuriootpa, SA, 25 July 2018
- E.N. Wilkes, Maximum residue limits, an expensive habit, FIVS meeting, Honolulu, Hawaii, 9 October 2018
- S. Nordestgaard, Trends in Australian grapegrowing practices, AWRI roadshow seminars, Griffith, NSW, 8 May 2019
- S. Nordestgaard, Trends in Australian grapegrowing practices, AWRI roadshow seminar, Mildura, VIC, 9 May 2019
- S. Nordestgaard, Trends in Australian grapegrowing practices, AWRI roadshow seminars, Loxton, SA, 10 May 2019
- S. Nordestgaard, Inspirations from the past and opportunities for the future, 17th AWITC plenary program, Adelaide, SA, 24 July 2019
- S. Nordestgaard, Trends in Australian grapegrowing practices, AWRI roadshow seminar, Coonawarra, SA, 28 October 2020
- E.N. Wilkes, Low- and no-alcohol wines, some challenges, International Wine Law Conference, McLaren Vale, SA, 18 September 2021

Posters

- E.N. Wilkes, M. Wheal, A periodic table of wine composition, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- E.N. Wilkes, P.W. Godden, S. Guy, L. Hoxey, B. van Eyssen, Trends in Australian wine composition, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, E.N. Wilkes, Cold stabilisation: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, E.N. Wilkes, Heat stabilisation: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, E.N. Wilkes, Bottle closures: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, Filtration: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, Flotation: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- S. Nordestgaard, In-tank fermentation monitoring: past and present, 17th AWITC posters, Adelaide, SA, 21–24 Jul 2019
- E.N. Wilkes, P.W. Godden, Variability of alcohol trends for different varieties of Australian wine, 18th AWITC posters, Adelaide, SA, 26-29 June 2022
- S. Madaras, L.E. Bey, E.N. Wilkes, Comparison of commonly used analytical methods for the analysis of alcohol content in wine, 18th AWITC posters, Adelaide, SA, 26-29 June 2022

Articles

- Godden P. W., Wilkes E. N. 2023. Trends in the composition of Australian wine 1990 – 2021 Part one: Introduction, titratable acidity (TA) and pH, *Wine Vitic. J.* Summer edition (in press)
- Nordestgaard S. 2019. AWRI Vineyard and Winery Practices Survey (Available for download at www.awri.com.au/survey)
- Nordestgaard S. 2019. Latest advances in grape sorting technology. *Aust. N.Z. Grapegrower Winemaker* (662): 50-55.
- Nordestgaard S. 2020. Inspirations from the past and opportunities for the future, Part 1: Cross-flow filtration and flotation. *Aust. N.Z. Grapegrower Winemaker* (676): 58-64.
- Nordestgaard S. 2020. Inspirations from the past and opportunities for the future, Part 2: In-tank fermentation monitoring and continuous processes. *Aust. N.Z. Grapegrower Winemaker* (677): 50-56.
- Wilkes. E.N. 2018 Metals in Australian wine. *AWRI Tech. Rev.* 233: 11-16.
- Wilkes. E.N. 2018 A snapshot of SO_2 concentrations in Australian wines. *AWRI Tech. Rev.* 236: 5-9.
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- Wilkes. E.N., Pride R. 2022 Comparison of common methods for measuring alcohol in wine. *AWRI Tech. Rev.* 257: 5-9.

11. Appendix 2: Intellectual property

Program IP has been communicated through presentations and publications and resides in the public domain. Copyright in any reports or presentations is held by the AWRI. Copyright in publications remains with the publisher. No inventions or patentable discoveries have been identified from the work. No Program IP has been commercialised or identified for commercialisation at the time of writing this report.

12.Appendix 3: References

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Wilkes, E.N., Godden, P.W. 2022. Variability of alcohol trends for different varieties of Australian wine. 18th AWITC poster, Adelaide, SA. Available from: https://awitc.com.au/program/poster-presentations/posters-download-2-2/

13.Appendix 4: Staff

Dr Eric Wilkes
Dr Simon Nordestgaard