Annual Report 2019
The Australian Wine Research Institute

Board members

Ms L.E. Rose
BAppSc (Oen), BSc, GAICD
Chair – Elected a member under Clause 25.2 (c) of the Constitution

Mr T.J. Bekkers
BAppSc (Ag) (Hons), Grad Cert (Mgt)
Elected a member under Clause 25.2 (c) of the Constitution

Ms W. Cameron
BAppSc (Biochem and Microbiol), MSc, BAppSc (Wine Sci), MW, GradDip (Ed), GradCert (Bus)
Elected a member under Clause 25.2 (c) of the Constitution

Dr J.S. Harvey
BSc (Hons), PhD, MBA, GAICD
Elected a member under Clause 25.2 (c) of the Constitution

Dr D.L. Johnson
BSc (Hons), PhD, MBA, GAICD
Ex officio under Clause 25.2 (a) of the Constitution as Managing Director of the AWRI

Mr I.M. Jones
BSc, MSc
Elected a member under Clause 25.2 (c) of the Constitution

Prof. K.D. Kirk
BSc (Hons), PhD, DPhil
Elected a member under Clause 25.2 (b) of the Constitution

Ms E.A. Riley
BAppSc (Wine)
Elected a member under Clause 25.2 (b) of the Constitution

Mr M.R. Watson
BEc, MBA, CA, RITP, MAICD
Elected a member under Clause 25.2 (b) of the Constitution

Mr M.Y. Woods
BAppSc (Vitic), MBA
Elected a member under Clause 27.1 of the Constitution (from 19 October 2018)

The company

The Australian Wine Research Institute Ltd was incorporated on 27 April 1955. It is a company limited by guarantee that does not have a share capital.

The Constitution of The Australian Wine Research Institute Ltd (AWRI) sets out in broad terms the aims of the AWRI. The AWRI's activities are guided by its business and research, development and extension plans, and its stated mission, values and behaviours:

Mission

Supporting the Australian grape and wine industry through world-class research, practical solutions and knowledge transfer.

Values

Values provide guidance in how the AWRI will deliver on its mission. These values are:

- Excellence
- Integrity
- Passion

Behaviours

Behaviours in support of those values are:

Excellence

- Outcomes focused, delivering results
- Personal mastery – being the best one can be
- Asking and answering the right questions
- Relevant to industry
- Collaborating to achieve faster, better or cheaper outcomes

Integrity

- Accountability to stakeholders
- Dealing honestly, impartially and consistently
- Scientific and professional rigour

Passion

- Enthusiasm for our people, our industry and our products
- Spirit of creativity
- Enjoying work and celebrating achievements
- Desire to do better
- Pursuing knowledge and understanding

The AWRI's laboratories and offices are housed in the Wine Innovation Central Building within an internationally renowned research cluster on the Waite Research Precinct at Urrbrae in the Adelaide foothills. Grape and wine scientists from other organisations are co-located with the AWRI in the Wine Innovation Central Building.

The Waite Research Precinct is also home to other research and teaching organisations including: Australian Centre for Plant Functional Genomics (ACPFG), Australian Genome Research Facility (AGRF), Australian Grain Technologies (AGT), Australian Plant Phenomics Facility, CSIRO, South Australian Research and Development Institute (SARDI), the University of Adelaide's *School of Agriculture, Food and Wine* and the Waite Research Institute.

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65th Annual Report – 30 June 2019
Presented to the Australian grape and wine community

Chair and Managing Director's report

Positive sentiments continue to be evident in the Australian grape and wine community. Despite some localised losses and fears of a subdued vintage size, solid overall yields were achieved in vintage 2019 (just 1% below the 10-year average). Both wine exports and grape prices are continuing to increase, with China the stand-out market. Industry sentiment at the recent Australian Wine Industry Technical Conference (AWITC) and WineTech was buoyant, with the event attracting the largest attendance in its 50-year history. Indeed, the scale, focus and volume of trading at WineTech points to a belief among producers and the industry supply chain that the industry is facing a positive trajectory.

Challenges are, however, ever present. The place of alcohol in society and the terms of trade among various industry participants continue to attract external scrutiny. Water access, climate variability, regulatory changes and biosecurity threats are among the issues that are keeping growers and winemakers up at night.

As our industry begins work towards a new long-term strategy, in a process led by Australian Grape & Wine and Wine Australia, the need for innovation – both collectively and within individual companies – cannot be overemphasised if we are to meet the opportunities and challenges we are facing. The AWRI exists to provide the technical support base for these innovations and the industry prosperity that they underpin.

Sustainable Winegrowing Australia

The formation of a unified national sustainability program, Sustainable Winegrowing Australia, was a major achievement during the year, and an example of what can be achieved when industry bodies work together to put Australian wine first. The program provides a unified sustainability framework for all Australian grapegrowers and winemakers to demonstrate their sustainability credentials, benchmark performance and identify opportunities for improvements. The launch of Sustainable Winegrowing Australia represents the culmination of several years of hard work and cooperation among a large number of wine sector people and organisations. The AWRI looks forward to continuing to work collaboratively with all stakeholders to support the program and grow its membership and its global impact. The program will continue to develop, with background research projects already underway and new modules and expanded scope under consideration.

AWITC

Any year that leads up to an AWITC is a busy one at the AWRI. It is the grape and wine industry's primary extension forum, and major commitments of time and effort are made by dozens of organisations to support this important triennial event. The AWITC has grown into a complex, multi-faceted event with several major partners. The contributions of all those involved, including every member of the AWRI team, are gratefully acknowledged.

Commitment to diversity

The AWRI was proud to be one of the first organisations to sign Australian Grape & Wine's Diversity and Equality in Wine Charter. This is not an end in itself, rather a public signal of commitment to treating all people with respect and fairness, maintaining a safe work environment and promoting a culture that values diversity. The AWRI already embodied those principles both because they are the right thing to do and because diversity of thought, skills and experience is directly beneficial to the quality of the AWRI RDE program. Of the AWRI's staff, 57% are women, with those individuals increasingly holding leadership roles; 20% speak English as a second language; and 17% were born and trained outside of Australia. The AWRI looks forward to supporting Australian Grape & Wine as it pursues the action plan associated with the charter.

Benchmarking grape and wine research globally

To ensure Australia is keeping pace with global benchmarks and that Australian grapegrowers and winemakers have access to world-class research and practical solutions to support their innovation efforts, during the year the AWRI sought independent assessments of its performance. The analysis focused on the quantity and quality of scientific output from the world's grape and wine research institutions over the last 15-20 years. Scientific publishing is by no means the end goal for AWRI research – rather, the end goal is industry uptake and innovation. However, scientific publishing can be considered the 'currency of science', is an important part of the process of innovation and contributes to international reputation and attractiveness for collaboration. It is therefore a useful basis for international comparisons and a (imperfect) proxy for international standing.

The analysis revealed that the AWRI is number one or two in the world among grape and wine research institutions on all major publication citation metrics, and second in terms of the volume of articles published. In particular, the quality of the AWRI's publications was assessed as a positive point of differentiation. When the results are normalised for R&D investment levels, the number of contributing scientists and the size of the national/regional grape and wine industry, the AWRI is arguably a world leader. These results present a positive picture of the quality and breadth of the research conducted by the AWRI and its industry and research collaborators.

However, the analysis also highlighted areas of caution. The volume of output in grape/wine research in Australia is likely static or declining, largely because of declining investment (in both absolute and real terms) from traditional sources. Over the last decade the AWRI has seen annual improvements in the number of scientific publications per dollar of investment, but there's a limit to how far efficiency can be stretched without compromising quality. Meanwhile, institutions in several other countries have scaled up their research efforts at a significant rate and overtaken Australian research institutions in terms of the quantity of output. If Australia considers it important to be a world leader in terms of the scale of grape/wine science output, it must

Louisa Rose, Dan Johnson

give serious attention to lifting RDE investment levels. Industry RDE levies rise and fall with production each year, but the levy rates have not risen since the early 2000s. Although reforming or raising industry levies is difficult at any time, the current industry-wide strategic planning exercise and generally positive industry sentiment present an opportunity to set the industry up for a sustainable future with an appropriate RDE levy that keeps pace with international benchmarks.

A key driver of the standing of the AWRI's research program is the close involvement of the industry-elected AWRI Board. The AWRI Board regularly monitors the strategic direction and operational performance of the AWRI's research activities, and from time to time invites expressions of interest for an internally funded 'blue sky' research program to ensure that the portfolio remains current and that all worthy research ideas are being pursued. One such round was undertaken in 2018/2019 and the projects will run in the coming years.

Evaluating extension and adoption

The AWRI also recently commissioned an independent evaluation of its extension activities to understand the appropriateness and effectiveness of extension services and events, and to contribute to a Wine Australia evaluation of the extension programs in which it invests.

Three surveys were developed and implemented. Surveys were sent to stakeholders who had used AWRI extension services or attended extension events since July 2017. In total 733 survey responses were received. With a population of approximately 1,900 people eligible for the surveys, this represents a 39% response rate, giving a high degree of confidence in the reliability of the results.

The evaluation found that the content and delivery methods of AWRI extension activities meet the needs of those using them. Specific findings include:

- Extension activities are increasing knowledge of respondents and increasing their confidence to make decisions. Importantly, this is translating into adoption of new practices, or changes being made to practices. After accessing AWRI services, 66% of respondents adopted new practices or changed their practices, and after attending AWRI events that metric was 82%.
- Respondents use the full suite of AWRI extension services, with the most commonly used services being the website (96% of respondents) and the helpdesk (81% of respondents).
- More than 91% of respondents had attended at least one AWRI event, with the most highly attended events being the roadshow seminars (74%), roadshow workshops (57%) and webinars (53%).
- The usability of information from extension events was high, with 87% of respondents stating the usability of information was 'above average' or 'excellent'.

HR survey

Another important assessment of the AWRI's performance as an organisation comes from the annual internal HR survey and associated metrics. It is extremely pleasing to see that 9 in 10 employees consider the AWRI to be an employer of choice, with even more agreeing (around three quarters strongly so) that 'all things considered, the AWRI is a great place to work'. Other feedback highlights the value placed on flexible working arrangements, support for professional development and the quality of the AWRI's facilities, while the professionalism and supportive nature of its people and the ability to work closely with industry remain recurring themes. Additional internal statistics show the AWRI's workforce to be the largest it's ever been, with the average tenure the longest in recent history – the result is a cumulative 1,071 years of service from 138 staff.

AWRI Commercial Services

AWRI Commercial Services again achieved records in both turnover and daily sample numbers (now handling ~112 samples per day) and continued its strong performance in both traditional and new areas of activity.

Expansion of metabolomics service program

The AWRI was delighted to secure >$10 million over the next four years, primarily through Bioplatforms Australia and the Government of South Australia, for the expansion of the AWRI's metabolomics service platforms. Since its commencement in the mid-2000s, this service has become an integral part of the AWRI's research program and service platform, and has seen successful collaborations within the wine research community and across a range of agricultural science projects.

Collaborative framework

The international grape and wine research community took another step forward this year, receiving one of the first ever EU-sponsored grants for researcher exchange. Thirteen consortium partners across the EU and New World wine-producing countries jointly applied to allow grape and wine researchers from the EU to spend time on sabbatical at either industry organisations in the EU or at relevant research institutions in the New World. More than $1 million will be provided by the EU for 39 research exchanges, of which 11 relate to EU researchers from France, Spain and Portugal undertaking visits/sabbaticals at the AWRI, with an expected collective duration of four years. The collaborations and information exchange arising from these sabbaticals will have enduring benefits.

Collaboration is an essential part of the AWRI culture. An analysis of the last ten years of AWRI publications in the Web of Science reveals that 79% of AWRI papers also listed a non-AWRI affiliation. Affiliated partners cover some 263 institutions from around the world, with ten institutions representing two-thirds of those collaborative linkages.

Technical trends from the AWRI helpdesk

As with previous years, the nature of the industry's technical support needs over the past 12 months was reflected in the volume, timing and topics of the enquiries answered by the AWRI helpdesk team, and the associated extension activities of the AWRI as a whole. The enquiries received were strongly influenced by climatic conditions during the growing season and over vintage.

During winter and spring, queries were received about the dry conditions that occurred during the growing season, particularly across the eastern states. The general trend experienced by most growing areas was a dry winter followed by a hot summer. Clear spring nights resulted in some regions experiencing severe frosts, with yield being further reduced in some cases by strong wind and hail. Information prepared following the 2017 harvest frosts was distributed to growers affected by frost. Tropical thunderstorms in October and November across the eastern states raised concerns about disease, particularly downy mildew, and efforts to shore up chemical controls were put in place. A webinar was held in November covering control strategies for downy mildew and *Botrytis*. The predominantly hot and dry summer conditions then removed most of the disease threat and reduced canopy vigour. Some vineyards reported yield loss and rapid fruit maturity due to extreme hot weather events after veraison.

Biosecurity queries about the possible importation of brown marmorated stink bug (BMSB) were received from growers. Additional queries came from wineries and organic regulators concerned about the implications of fumigation and heat treatments imposed on shipments of oak barrels and glass bottles as one of the biosecurity measures to prevent a BMSB incursion. The AWRI prepared and disseminated information on alleviating any potential risks from treated winemaking products. Discussions were also held with the Organic Industry Standards and Certification Council regarding labelling of organic wines made using barrels, corks or bottles that had been fumigated. Biosecurity seems set to remain an important industry priority.

A number of vineyards indicated that they had encountered grapevine viruses, particularly leafroll virus, in young vineyards during the season. A panel-style webinar on viruses was presented to more than 70 growers. In February 2019, the AWRI hosted an industry reference group discussion about an apparent increase in incidence of scale and mealybug in conjunction with virus symptoms being observed in vineyards around Australia. Viruses are becoming an increasing area of focus in many of the world's major grapegrowing regions.

The largest number of queries received this season were on smoke taint. Bushfire events occurred across six states. The helpdesk team worked with regional associations in affected areas, coordinating smoke taint Q&A events and setting up a centralised sample submission process for smoke taint analysis. Updated smoke taint fact sheets were provided to all affected regions. While our industry has learned much about managing the impact of smoke events, each event brings new learnings and refinements to the analytical and evaluation methods, and the interpretation of smoke chemical marker analysis.

Following the warmest December and January on record, including several heatwaves throughout January and February in South Eastern Australia, there was initially a delay in ripening, followed by rapid fruit maturation, high Baumé fruit and a compressed harvest. In many regions it was possible to mitigate the effects of heat and dryness through good canopy management and irrigation, and the dry conditions also reduced disease pressure. Lower yields were also offset by excellent wine colour and flavour in many cases.

Many of the topics dealt with by the AWRI helpdesk each year are directly or indirectly linked to a variable climate and/or extreme weather events. This year these included sunscreen use during heatwaves, hydraulic oil contaminations likely related to the pressures of a compressed vintage, higher than normal acetic acid levels in some white fermentations and disparities between initial Baumé readings and final alcohol concentrations, possibly caused by small berry sizes from the dry season. On the positive side, high grape nutrient levels seen early in the season may help to explain why stuck fermentations were not a major problem this season compared to other heatwave-affected years. In addition, lower yields in some areas meant winemakers may have had more tank space available than in other compressed seasons, helping to ease logistical pressures.

In contrast to the eastern states, Western Australia experienced an unseasonably cool spring that affected flowering, followed by cool, wet, maritime summer conditions, resulting in a delayed harvest. The helpdesk received queries about the impacts of *Botrytis* in some WA vineyards.

Securing access to water of the right volume and quality, at the right price and at the right time of year, seems set to dominate industry decision-making in many regions. Both vineyards and wineries faced water limitations during the season due to the extended drought conditions across South Eastern Australia. Limited water availability prevented use of irrigation to manage heatwaves in some vineyards and rising salinity levels in some water catchments reportedly increased soil salinity via irrigation. A number of wineries sought information on the use of alternative water sources such as ground, bore or mains water, or shipping in rainwater via tankers to refill empty tanks, for water addition to dilute high Baumé musts. Methods on how to add water and how to remove chlorines from water before addition to musts were commonly requested during the vintage. The AWRI website water addition calculator was used 1,345 times.

Looking towards vintage 2020

A positive Indian Ocean Dipole is likely to form in spring 2019 (BOM Climate Outlook August - October 2019). This typically favours drier conditions throughout Australia and thus a likely continuation of drought conditions in the eastern states. Despite these challenges, however, the story of Australian wine continues to be one of resilience. Wines of superb quality continue to be made all around the country, and those wines continue to be enjoyed by consumers the world over.

At the AWRI, 2019/2020 will bring a continued focus on delivering the projects in the AWRI RDE plan. The business and operational side of the organisation will also receive attention, with the conclusion of *AWRI Directions 2018-2020* and work towards the preparation of a subsequent AWRI Directions plan. The year will also see:

- new whole of industry strategic vision and RDE plans
- internal and external reviews of several lines of RDE activity
- commencement of several internal blue sky projects
- completion of several long-running projects, including the international collaborative project to produce a synthetic yeast genome
- roll-out and further development of platforms including Sustainable Winegrowing Australia and ShowRunner
- commencement of a new Applied Biosciences team within AWRI Commercial Services
- a Board nomination and possible election process for one Board position in each of the small, medium and large levy payer categories.

Thanks

The AWRI works closely with hundreds of grapegrowers and winemakers, provides services to a wide range of investment partners and clients, and operates more than a hundred active research collaborations – acknowledgement and thanks are expressed to each of these partners. The wine industry bodies Australian Grape & Wine and Wine Australia are particularly thanked for their strategic and financial support.

The AWRI Board is also warmly thanked for its commitment and contributions during the year. Marcus Woods was welcomed to the Board in October 2018 and is acknowledged for his commitment to the AWRI since his commencement.

The contents of this annual report highlight just some of the outstanding achievements of the talented AWRI team, who are all thanked for their hard work, enthusiasm, dedication and service to our industry.

Louisa Rose
Chair

Dr Dan Johnson
Managing Director

Board notes

Dan Johnson | Marcus Woods | Kiaran Kirk | Toby Bekkers | Liz Riley

Chair
Ms L.E. Rose

Audit committee
Mr M.R. Watson (Chair)
Mr T.J. Bekkers
Dr J.S. Harvey

Personnel committee
Ms L.E. Rose (Chair)
Mr M.Y. Woods
Prof. K.D. Kirk

Meetings

Ordinary General Meeting
The 64th Ordinary (Annual) General Meeting was held on 4 December 2018.

Extraordinary General Meeting
There were no Extraordinary General Meetings held.

Board
The Board of the AWRI met on the following dates: 18 September 2018, 4 December 2018, 27 February 2019 and 3 and 4 June 2019.

John Harvey | Louisa Rose | Mark Watson | Wendy Cameron | Iain Jones

Investment

The Board of the AWRI acknowledges the continuing financial support of Wine Australia, the Government of South Australia, the Australian Government Department of Agriculture and Bioplatforms Australia, along with a large number of confidential commercial clients.

Appreciation

The activities at the AWRI benefit from collaborations with individuals and organisations from the following countries: Australia, Canada, Chile, China, France, Germany, Indonesia, Italy, Poland, UK and USA. The assistance and cooperation from partners across the globe are gratefully acknowledged.

Highlights of the year

Customers, consumers and markets

Australian wine industry adapting to regulatory changes in export markets

Analysis of residues in Australian wine demonstrated that early action by the Australian wine industry has helped limit the impact of regulatory changes in export markets. The number of wines with detectable residues of iprodione (now banned in Europe) has reduced rapidly over the past three vintages from 25% of surveyed wines in 2016 to less than 3% in 2018. Chlorothalonil (also banned in Europe) has not been detected in any wines since vintage 2016. Glyphosate levels were also below the Australian maximum residue limit (MRL) for all surveyed wines.

International ring test program continues to grow

The international ring test program managed by the AWRI continued its success in aligning the analytical capabilities of a range of APEC nations which import and export wine, helping to reduce incidents of wine being rejected in market. Plans are in place for the 2020 program to be expanded to more than 20 countries, including emerging wine importers in Africa, India and South America, using funding secured from the Australian Government by Australian Grape & Wine.

Agrochemical support provided

Three new active constituents were registered for wine-grape production: acetamiprid, pyriproxyfen and mefentrifluconazole. Sensory analysis and residue data were reviewed to assess the suitability of these constituents for use in wine production and to establish withholding periods for wines destined for export. Agrochemical information was provided to stakeholders via eight *eBulletins,* including notification about an emergency permit for the use of certain metalaxyl and metalaxyl-M products for downy mildew infections and advice on a permit allowing the use of fipronil for wasp control.

Improvements to agrochemical and MRL digital tools

Redevelopment of the agrochemical and MRL databases commenced during the year. The agrochemical mobile app has undergone a major upgrade with a new MRL search function added.

Success with new sensory method

The sensory analysis method projective mapping with preference/choice was found to provide a detailed picture of consumers' preferences and attitudes to wines, giving insight into both their sensory response and their reaction to wine labels or information provided about the wines being tasted.

Extension, adoption and education

Helpdesk support

The AWRI helpdesk responded to 1,959 enquiries, conducted 222 investigations and analysed more than 950 samples. Key areas where queries were received included smoke taint, climate, sustainability, biosecurity and grapevine viruses.

Extension survey

The AWRI commissioned an external consultant to survey people who had attended AWRI extension events to understand the level of adoption and practice change occurring based on the content presented. The survey covered all the AWRI's extension events including the roadshow seminars and workshops and the more recent winemaking treatment workshops. Results showed that of people who attended an AWRI seminar or workshop, 82% of respondents adopted a new practice or changed their practices.

Seminars and workshops

During the year, 17 roadshow seminars and 33 workshops were held in winemaking regions across Australia (see Appendix 2 for details). Of the 33 workshops, 24 were winemaking treatment tastings, with Cabernet Sauvignon the third variety to be showcased since the launch of this workshop format in 2017. This workshop demonstrates a range of different treatments made to a single batch of grapes and shows what happens to a wine stylistically when one variable is changed at a time. Of the respondents to the AWRI's extension survey who had attended a winemaking treatment tasting workshop, 58% indicated they had changed a practice based on information they had seen presented. Other workshops during the year covered spray application, addressing regional challenges and smoke taint. A total of 1,223 participants attended seminar and workshop events in 2018/2019.

Wine Australia Regional Program

The AWRI assisted in coordinating the design and delivery of extension and adoption activities within the program's 11 regions. The annual meeting of the regional partners was held in Stanthorpe, Queensland in July 2018, and included discussions on alternative varieties, soft pruning and pest and disease management.

ShowRunner
During the 2018 wine show season 31 shows used the ShowRunner platform, including the National Wine Show of Australia – the first capital city wine show to adopt the system. An extra module has been developed which allows use of a modified version of Show-Runner as an internal grading and classification tool for wines.

Library services
The John Fornachon Memorial Library launched a new online library catalogue, which provides significant improvements in user experience and collection accessibility. The library's collection grew by around 4% during the year and now includes more than 101,000 items. In 2018/2019 the library responded to 885 reference enquiries; delivered 1,907 articles; conducted 64 specialist literature searches; and expanded its eBook collection to more than 160 titles.

Webinars
Fifteen webinars were presented in 2018/2019 to a total of 610 attendees. Webinar recordings on the AWRI's YouTube channel were viewed more than 9,500 times, almost three times more views than the previous year. Webinars covered a wide spectrum of topics, with a focus on viticulture, including biosecurity, vine balance, salinity, antitranspirants, trunk disease, water management and climate forecasting.

In-person interactions
Throughout the year AWRI staff gave 268 external presentations, coordinated 74 events, conducted 44 media interviews, presented 21 lectures to university students and supervised or co-supervised 16 students.

Publications
In 2018/2019 AWRI staff authored 103 peer-reviewed and non-peer-reviewed papers for scientific journals and industry publications.

Stakeholder communications
Three AWRI reports and three columns on alternative varieties were published in the *Wine & Viticulture Journal*. Twelve 'Ask the AWRI' columns covering topical issues from the AWRI helpdesk were published in the *Australian & New Zealand Grapegrower & Winemaker*. New technical literature published from around the world was abstracted in six issues of *Technical Review*. Grapegrowers and winemakers were alerted to topical issues in 21 *eBulletins* issued through the year. Updates of AWRI activities were provided in six issues of *eNews*, emailed directly to producers. More than 150,000 visitors accessed the AWRI website during the year, an increase of 23.1% increase from the previous year, with more than 540,000 page-views.

Social media engagement
The AWRI's Twitter following grew by more than 120 during 2018/2019 to reach 3,515. The AWRI's Facebook presence also grew by almost 250 likes during the year to reach 1,250. The AWRI's YouTube channel includes AWRI webinar recordings and other AWRI video content. Subscribers grew by more than 200 during 2018/2019 and the channel attracted more than 9,500 views.

Performance, products and processes

Enhanced 'fruity' characters through foliar sprays
Foliar application of nitrogen and sulfur on Shiraz and Chardonnay grapevines greatly enhanced 'grapefruit' and 'tropical fruit' sensory characters in both varieties through formation of thiol compounds. Application of such sprays provides a straightforward way for producers to enhance thiol-related 'fruity' characters in wines, including in warmer regions.

Ability to influence 'peach' character in Chardonnay winemaking
Certain fermentation-derived esters were identified as contributing to 'peach' character in Chardonnay wines. As the formation of these compounds is quite well understood, winemakers can adjust the production of these 'peachy' esters during fermentation through simple practices such as oxygen management, decreased juice clarification, yeast selection and lees contact.

Whole bunch fermentation gives 'green' characters in Shiraz and Pinot Noir
A winemaking experiment with Shiraz and Pinot Noir investigated the impact of an increasing proportion of whole bunches in the fermentations. For both varieties a linear increase in 'capsicum' aroma and flavour was seen with an increasing proportion of whole bunches, as well as an equally strong linear increase in isobutyl methoxypyrazine concentration. These results provide confirmation that inclusion of grape stalks in wine fermentations can change flavour towards 'green' attributes. Effects on tannin and colour were also noted. Specifically, whole bunch fermentation for Pinot Noir was found to reduce total concentration of pigmented material and the perception of brownness in wine, enhancing the overall visual red colour of the wines.

Further understanding of formation of aged characters in Riesling
In a continuing collaboration with Hochschule Geisenheim University, Germany that aims to understand the formation of TDN (1,1,6-trimethyl-1,2-dihydronaphthalene, a 'kerosene-like' character) in Riesling, different types of shade cloth were used in a vineyard experiment to manipulate the light reaching the bunch zone. A clear decrease in total TDN was seen in juice at harvest as a result of the shade cloth treatments, with the decrease related to the amount of light transmitted to the bunches. Work is underway to identify the specific precursors to TDN.

Investigating indole in sparkling wine
Initial investigations of the formation of the off-flavour compound indole (described as 'chemical', 'plastic', 'mothballs') in tank method sparkling wine production suggest that indole is produced via a yeast-mediated metabolic pathway. Next steps will involve studies to investigate in more detail the sensory significance of indole and other related compounds that may also be involved in the off-flavour.

Metagenomics sheds light on differences in ability to perceive glycosidically bound flavour
Metagenomic studies of different types of bacteria in saliva showed individuals could be separated into two major groups, which related to their ability to break down glycoside flavour precursors and release the bound flavour molecule. However, the capacity of individuals to perceive flavour from glycosides was best predicted by their innate sensitivity to the flavour compound itself, showing that even those with low ability to break down glycosides had sufficient bacterial enzyme activity to release flavour.

WenWen Jiang, Yevgeniya Grebneva

Timing of formation of bitter compounds revealed

Winemaking trials showed that bitter sulfonated phenolic compounds are produced after the addition of SO_2 at the end of fermentation and that their formation occurs more readily at higher pH. In addition, a sensitive analytical method was developed using HPLC with fluorescence detection to quantify bitter sulfonated indole derivatives directly in wine without prior clean-up. The new method is more sensitive than previous methods, detecting compounds of interest at less than 1 mg/L.

Tracking polysaccharides during white winemaking

The evolution of polysaccharides during white winemaking from crushing through to bottling was determined for the first time. Interestingly, the concentration of high molecular weight polysaccharides that assist in protein and cold stability was stable during juice settling but increased throughout fermentation to the pre-bottling stage.

Zeolite found to be a promising bentonite alternative

Zeolite in the size range of 20-50 microns was shown to be effective in heat stabilising white wine. Zeolite does not exhibit the same swelling behaviour as bentonite, meaning that lees production (and associated wine loss) may be significantly lower. Zeolite was also found to selectively remove potassium (more than 30%), presenting the potential to also contribute to improved cold stability.

Aeration effects on wild ferments explored

For the first time, experiments were conducted to assess the effects of aeration on uninoculated Chardonnay ferments, comparing three different timings of applying aeration. The effect of aeration on the duration of the uninoculated fermentations was found to be more pronounced than for inoculated ferments, being reduced by as much as seven days. The effect on the microbiological community structure is being assessed using metagenomics. The effects of SO_2 additions on wild ferments were also assessed.

Existing winery technology may be useful for aeration of large-scale fermentations

Mapping of oxygen accumulation during Pulsair® mixing operations in commercial fermentation vessels revealed a potential alternative method for aeration of large-scale fermentations using equipment already installed in many wineries. Pulsair® air mixing equipment is most commonly used in larger wineries for cap management. Results suggest that this equipment, where fitted, could also be used to implement an aeration strategy during fermentation.

Assessing how much oxygen is too much during red and white fermentations

Pilot-scale trials assessed the limits of ferments to absorb aeration without developing negative 'oxidative' characters. Perhaps unsurprisingly, aeration thresholds in white ferments were found to be much lower than in red ferments.

Glutathione utilisation by yeast

Sulfur isotope-labelled glutathione was used for the first time in experiments in the 2019 vintage investigating the fate of added glutathione. Glutathione added to fermenting must was shown to be utilised by yeast even when the glutathione addition rate was low. The degree to which this occurred was dependent on both must nitrogen status and yeast strain.

'Rose' yeast applications explored

Saccharomyces cerevisiae strains with a range of 2-phenyl ethanol ('rose' character) production capabilities were assessed both for their sensory impact and for their potential as active dried yeast. Pilot-scale trials also assessed the potential of third generation 2-phenyl ethanol overproducing yeasts for use in sparkling wine production.

Contribution of hybrid yeast to non-volatile wine composition

An exploration of the impact of different interspecific hybrids on the concentration of non-volatile components of wine demonstrated that the majority of the effect was related to the *Saccharomyces cerevisiae* parent used to construct the hybrid. This result will inform future approaches to selecting parental strains for the generation of wine yeast hybrids.

Understanding SO_2 production by yeast to inform co-inoculation of malolactic fermentation

Measurement of SO_2 production during fermentation by both high- and low-SO_2-producing yeasts showed differences in the rate of SO_2 production that related to yeast strain. Using this information, a window for optimal *Oenococcus oeni* co-inoculation was predicted and experimentally evaluated. This data will be used to refine recommendations for the conduct of concurrent alcoholic and malolactic fermentation. Experimental evaluations of *O. oeni*/wine yeast strain interactions during co-inoculation of white wine fermentations also demonstrated that survival of *O. oeni* was possible even in co-fermentations where high concentrations of SO_2 were produced by wine yeast. The ability of *O. oeni* to survive in these conditions was shown to be dependent on wine yeast strain, suggesting that there are other factors contributing to bacterial survival.

Objective measures of quality and provenance in Shiraz

The AWRI is participating in a new study of Shiraz terroir in the Barossa as part of a multi-agency collaboration, led by the University of Adelaide. At the sub-regional scale, 23 sites were monitored with fruit undergoing sampling for ripeness, yield assessment, chemical analysis and small-lot winemaking. Using multivariate modelling, the wines from Eden Valley could be successfully distinguished from the other Barossa sub-regions. In a separate Shiraz terroir project, the main sensory attributes that differentiate Shiraz wines from six different regions were successfully related to a small set of key chemical measures. Once confirmed, this knowledge will provide targets for tuning of grapegrowing and winemaking practices to optimise distinctive flavour properties.

Digital solutions for grape quality measurement and management

A project assessing digital methods for rapid assessment of grape quality on delivery to the winery was completed during 2018/2019. Hyperspectral imaging (HSI) of samples in the laboratory could discriminate clean and *Botrytis*-infected red and white grapes. The technique could also differentiate between *Botrytis* infection and sour rot (mixed fungal and bacterial infection of grapes). In addition, HSI could identify sunburn in white grapes and shrivel in red and white grapes, and detect other non-grape components that are often found in mechanically harvested grapes.

Average SO_2 tolerance of *Brettanomyces* industry isolates increasing over time

Analysis of *Brettanomyces* strains isolated from wineries has shown a definite shift in SO_2 tolerance over time, with the average tolerance of isolates from 2016 to 2018 approximately equal to the highest tolerances observed in isolates from 2000 to 2004. Genetic testing will be used to determine if these more tolerant isolates are from known genotypes that are evolving increased tolerance or new genotype(s) not observed previously.

Comparing strategies to remediate volatile sulfur compounds in wine

Five commonly used strategies for remediating 'reductive' characters in wine were compared. Overall, the combination of macro-oxygenation and copper fining was most effective in giving lowest 'reduction'-related attributes while enhancing 'fruity' attributes, whereas copper fining alone, lees addition and (to a lesser extent) diammonium phosphate (DAP) addition were shown to diminish 'fruity' attributes and confer 'reductive' characters.

Improved understanding of use of filtration to remove sulfides bound to copper

Nanoparticle tracking analysis showed that copper sulfide particles (which may be formed in wine following treatment of 'reductive' characters with copper) can be partly removed by adsorption onto membrane filters, with some membrane types better than others at removing the copper sulfide particles. This finding sheds some light on what is happening in wine when winemakers treat 'reductive' wines with copper sulfate and then aim to use filtration to remove the copper sulfide particles.

Molecular marker for thiol release by wine yeast

The yeast enzyme IRC7 has been identified as having a key role in the release of 'tropical' thiols from odourless precursors. Significant diversity has been found in the thiol-release capability of different wine yeast strains. IRC7 could be used as a molecular marker to predict a yeast's potential to release 'tropical' thiols.

Investigating factors influencing formation of reductive characters in canned wines

Commercial canned wines exhibit a significant increase in aluminium concentration and elevated levels of hydrogen sulfide (H_2S) during storage. The impact of aluminium increase on H_2S formation is lower with higher pH, higher oxygen concentration, decreased sulfur dioxide and lower copper concentration. The use of commercially available cross-linked polymers to sequester copper from canned wines can be an effective strategy to reduce the impact of aluminium transfer during storage.

Assessing variability across a smoke-exposed vineyard

Variability among grapes across a vineyard exposed to smoke during fires in 2018 was assessed in two blocks (one Chardonnay, one Pinot Noir). For the majority of grape samples (90% for Pinot Noir and 100% for Chardonnay), the levels of volatile phenols and smoke glycosides were relatively consistent (within 20% relative standard deviation of the mean) and all samples had concentrations of exposure markers above those observed for 'clean' grapes in previous baseline studies.

Trialling activated carbon treatment for smoke taint remediation

Activated carbons were trialled as a treatment for juice from smoke-affected grapes prior to fermentation, with winemaking trials undertaken on two juices (Pinot Noir and Chardonnay). Reductions in smoke glycosides were achieved with increasing doses of activated carbon removing more of the glycosides. Sensory impacts of the treatment on the wines made from the treated juice will be assessed.

Environment, sustainability and natural capital

Progress towards national sustainability program

Following the previous year's independent review of Australian wine's place in the global sustainability landscape, an implementation plan for a unified national sustainability program was developed and subsequently agreed by the AWRI, Australian Grape & Wine and Wine Australia. In preparation for launch of the new program (to be known as Sustainable Winegrowing Australia), a new database was developed and progress was made towards the collection and benchmarking of economic metrics.

Use of isotopic ratios for provenance testing expanded

Work continued towards the goal of developing a robust way to determine the provenance of an unknown wine sample using isotope ratios and a matrix of elemental concentrations. The initial promising results achieved using strontium isotope ratios were expanded with the inclusion of data on the isotope ratios of boron, lithium and lead. Lead ratios were found to differentiate wine samples by grape colour, so were excluded from the data set. Using boron, lithium, oxygen and strontium isotope ratios it was possible to differentiate Australian wines from those produced overseas (97.6% Australian wines correctly classified). Differentiation of production regions within Australia was also possible.

Bioprospecting Australian wine yeast

More than 2,000 ferment samples from 34 wineries around Australia were analysed across the 2016-2018 vintages using metabarcoding techniques. This data source is now providing information on the microbial variability that can occur across vintages in addition to that between different wineries or even between ferments performed in the same winery. Approximately 9,500 yeast isolates (*Saccharomyces* and non-*Saccharomyces*) have been added to the AWRI Wine Microorganism Culture Collection as part of this project. These yeast strains provide a valuable genetic resource that is currently being mined for the next generation of commercial wine yeast strains for the Australian wine industry.

Formation of precursor is key to rotundone concentration in grapes

Elevated concentrations in grapes of the neutral sesquiterpene α-guaiene are required for formation of the 'peppery' aroma compound, rotundone. That is, the key to obtaining 'peppery' Shiraz wine is to trigger and/or stimulate formation of α-guaiene in grapes. Grape α-guaiene and rotundone concentrations can be influenced by harvest timing. Earlier harvest reduces the likelihood of obtaining 'peppery' aromas and late harvest increases their likelihood. Vineyard soil microbiology may also be associated with elevated grape rotundone.

Genome sequencing of downy mildew strains

Genome sequencing and assembly have been performed on five *Plasmopara viticola* (downy mildew) strains isolated from around Australia to provide a baseline measurement of genetic variation across this species.

Foundational data and support services

Continued growth in analysis by AWRI Commercial Services

In 2018/2019 the Commercial Services laboratories processed more than 27,000 samples, an increase of more than 7% compared to the previous record year. A total of 183 new customers were added, compared to 172 in the previous year.

Vineyard and winery practices survey results released

A report summarising results from a major survey of Australian vineyard and winery practices was released. On the vineyard side, it covers areas including vineyard layout, pruning, pest and disease management, canopy management, irrigation, nutrition, vineyard floor management and harvesting. For wineries, it covers grape intake and handling, draining and pressing, juice processing, alcoholic and malolactic fermentation, maturation, fining, filtration and packaging. The information presented allows growers and winemakers to compare their practices with national and regional results. The full report is available for download at www.awri.com.au/survey.

Identification, storage and distribution of microbial strains

A total of 2,690 yeast and bacterial strains were submitted to the AWRI Wine Microorganism Culture Collection (AWMCC) from researchers and wineries, including almost 2,300 from the bioprospecting project. This brings the total in the collection to approximately 18,900. During the year, the AWMCC distributed 637 microbial samples from cryogenic stocks. A new robotic incubator was installed to complement the high throughput liquid handling robot to be used for future high throughput screening of the culture collection. Microorganism handling procedures were also reorganised to more efficiently comply with legislative requirements.

WIC Winemaking Services

WIC Winemaking Services processed 451 (6-150 kg) ferments during the 2019 vintage. A new capability to produce bottle-fermented sparkling wine was introduced.

Streamlining of sensory analysis

Sensory data acquisition was streamlined through complete transfer of methods to tablet computers, greatly improving efficiency and the ability to record results of sensory tests.

SO_2 survey completed

An extensive survey of free and total SO_2 levels in 3,000 Australian wines was conducted. Results showed that Australian wines are compliant with international regulations and that levels of free SO_2 are generally similar across red and white wines.

Significant investment in metabolomics

Bioplatforms Australia, which manages funding through the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), together with the South Australian Government and the AWRI announced a collective investment of $11.1m for metabolomics and associated activities at the AWRI from 2019 to 2023. This significant funding boost builds on the success of the AWRI's existing metabolomics facility, which was established in 2008. The facility supports local and national researchers and industries through the development and provision of metabolomic analysis.

In 2018/2019 Metabolomics SA successfully completed 59 jobs for clients across food and beverage, agriculture, biomedical and material science sectors. The facility's service portfolio was expanded to include accurate quantitation of plant hormones; vitamin K2 screening; accurate quantitation of tryptophan metabolites; quantitation of ethylene emissions in rice and wheat; and herbicide product screening.

Bioinformatics tool shared

The MStractor workflow, a bioinformatics tool for pre-processing raw data from LC-MS and GC-MS non-targeted metabolomics experiments, was published on GitHub, a software development and sharing online platform, making it freely accessible for the wider metabolomics community. The workflow has been adopted by other Metabolomics Australia nodes.

Electronic platforms implemented

New platforms were tested, configured and rolled out for the management of employee expenses and leave applications, to achieve operational and administrative efficiencies across the organisation. An online portal was created for the AWRI Board to access papers electronically, improving the efficiency of the process of preparing Board papers.

New Applied Biosciences team in AWRI Commercial Services

A new team, Applied Biosciences, has been created within AWRI Commercial Services to take advantage of molecular techniques in microbiological testing and increased interest in the biological aspects of grape and wine production. The team's activities will encompass all current microbiological testing, virus testing and elimination, site and bottling line audits and new molecular-based testing services. The team will also continue to expand the offerings provided to the brewing industry.

New IT Strategic Plan

Following the successful delivery of the AWRI's first IT Strategic Plan, this year saw the development and approval of the next IT Strategic Plan for the period 2019 to 2021, supported by the IT Strategic Reserve previously created by the AWRI Board. The plan includes such initiatives as the upgrade of the core network infrastructure, security updates, improving remote access procedures and real-time monitoring, local back-ups of cloud data and physical/virtual server upgrades.

Implementation of diversified portfolios for memorial trusts

Reflecting the changes made to the AWRI's investment portfolio in recent years, the assets of the four memorial trusts for which the AWRI acts as unrewarded trustee were migrated to more diversified investment portfolio structures. These changes are expected to provide the trusts with enhanced returns (in a risk-appropriate manner) that can be used to further achieve their objectives.

Acknowledgements

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Staff

The number of AWRI staff employed in a full-time, part-time and casual capacity as at 30 June 2019 was 135 (104.2 full-time equivalents). When the number of AWRI-based students (both from Australia and overseas) and visiting researchers is added, the total increases to 145. Of these, approximately 64% were funded by Wine Australia in 2018/2019.

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Casual sensory panel

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Jillian Lee, Customer Service Officer

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Lidia Delgado, *University of Nottingham, UK* visiting student (1/9/18-31/3/19)

Lisa Hartmann, *UniAdel*, PhD student

Jana Hildebrandt, *UniSA*, PhD student

Kristina Nobis, *Technical University of Dresden, Germany*, visiting student (1/10/18-31/8/19)

Elia Romanini, *Università Cattolica del Sacro Cuore, Italy,* visiting student (18/9/18-18/3/19)

Louisa Schueth, *Technical University of Dresden, Germany*, visiting student (29/1/18-23/7/18)

Visiting researchers

Felipe Laurie, *Universidad de Talca, Chile (3/9/18-31/1/19)*

Marc Pignitter, *University of Vienna, Austria* (28/2/18-31/8/18)

Bo Teng, *Sichuan University, China* (27/9/16-24/7/18)

Staff activities

Tadro Abbott is a member of the Entwine Reference Group and Entwine Technical Subcommittee.

Kate Beames is a member of the Australian Wine Industry Technical Conference Planning Committee.

Anthony Borneman is an Affiliate Lecturer at the University of Adelaide.

Natalie Burgan is Executive Officer for the Wine Innovation Cluster Leadership and Research Committees and a member of the planning committee for Crush – the grape and wine science symposium.

Bob Dambergs is an Adjunct Senior Lecturer at the University of Tasmania, a committee member of the Riverland Wine Industry Development Council, a committee member of the Riverland Winegrape Growers Association, a member of the Riverland Wine Technology Delivery Group and a Fellow of the Australian Society of Viticulture and Oenology.

Chris Day is a Chartered Accountant and a Director, Treasurer and Public Officer of the Australian Wine Industry Technical Conference.

Martin Day is a Chartered Chemist and member of the Royal Society of Chemistry (UK), and is a member of the editorial board of the Atomic Spectrometry Updates, published in the *Journal of Analytical Atomic Spectrometry*.

Peter Dry is an Adjunct Associate Professor at the University of Adelaide and Associate Editor of the *Wine & Viticulture Journal*.

Angus Forgan is a member of the South Australian Institutional Biosafety Committee Network Forum.

Leigh Francis is an Associate Editor of the *Australian Journal of Grape and Wine Research*; a member of the Editorial Board of the *Journal of the Science of Food and Agriculture*; an Affiliate Associate Professor at the University of Adelaide; and an Adjunct Associate Professor at the University of South Australia.

Peter Godden is an *ex officio* Councillor of the Royal Agricultural and Horticultural Society of South Australia, was a Panel Chair at the 2018 Barossa Wine Show and a judge at the 2018 Royal Melbourne Wine Awards.

Paul Henschke is an Associate Editor of the *Australian Journal of Grape and Wine Research*; an Affiliate Professor at the University of Adelaide; and Fellow of the Australian Society of Viticulture and Oenology.

Markus Herderich is an Affiliate Professor at the University of Adelaide; Director of the Australian Wine Industry Technical Conference; and member of the Metabolomics Australia Executive Management Group. He is also President of the Subcommission for Analytical Methods and expert in Commission-II (Oenology) at the Organisation Internationale de la Vigne et du Vin; a member of the Wine Industry Technical Advisory Committee; a member of the Wine Innovation Cluster Research Group; a member of the Advisory Board of the *Journal of Agricultural and Food Chemistry* and the Journal Advisory Committee of the *Australian Journal of Grape and Wine Research*.

Matt Holdstock is a Director of the Australian Society of Viticulture and Oenology.

Dan Johnson is Chair of the Australian Wine Industry Technical Conference, Honorary Adjunct Professor at Macquarie University Graduate School of Management and a Director of the National Wine Foundation. He is a member of the International Scientific Board of L'Institut des Sciences de la Vigne et du Vin, Bordeaux, France; the *World of Fine Wine* Editorial Board; the Wine Innovation Cluster Leadership Group and the Waite Strategic Leadership Group. Dan is a graduate of the Harvard Business School Authentic Leadership Development program; the Australian Wine Industry Future Leaders Program; the INSEAD Blue Ocean Strategy program; the IESE Creative Negotiation program; and the Oxford Advanced Management and Leadership Program.

Mark Krstic is a member of the Victorian Government's Wine Ministerial Advisory Committee; member of Hort Innovation's Table Grape Strategic Investment Advisory Panel; member of the National Wine Research and Extension Network; member of the National Viticulture Biosecurity Committee; Associate Editor of *Wine & Viticulture Journal*; Honorary Senior Fellow at the University of Melbourne; member of the Yarra Valley Technical Subcommittee; member of the Mornington Peninsula Vignerons Association Technical Subcommittee; member of the Australian Wine Industry Technical Conference Planning Committee; and a graduate of the Australian Wine Industry Future Leaders Program.

Natoiya Lloyd is a South Australian branch committee member and an analytical and environmental chemistry division committee member for the Royal Australian Chemical Institute.

Mardi Longbottom is a Director of the Australian Society of Viticulture and Oenology; Director of Australian Grape & Wine; member of the Limestone Coast Grape and Wine Council Technical Subcommittee; member of the Environmental Technical Committee of Freshcare Australia; Fellow of the Governor's Leadership Foundation Program; and a member of the Australian Wine Industry Technical Conference Planning Committee.

Brigitte Lynch is Secretariat for the Interwinery Analysis Group committee.

Jacqui McRae is a committee member for the SA Chapter of Wine Communicators of Australia; a member of the planning committee for Crush – the grape and wine symposium; a member of the Pint of Science SA organising committee; and a registered project manager with the Australian Institute for Project Management.

Agnieszka Mierczynska-Vasilev is a member of the Australia-China NanoNetwork, an initiative of the Australian Technology Network of Universities and the International Strategic Technology Alliance.

Thomas Hensel

Bryan Newell is a member of the Interwinery Analysis Group committee.

Simon Nordestgaard is Vice President of the Winery Engineering Association.

Wes Pearson is a committee member of the McLaren Vale Districts Group and a graduate of the Australian Wine Industry Future Leaders Program and the Len Evans Tutorial.

Paul Petrie is an adjunct Associate Professor at the University of New South Wales, an Associate Editor and member of the Journal Advisory Subcommittee for the *Australian Journal of Grape and Wine Research*; a member of the Australian Wine Industry Technical Conference Planning Committee; and Chair of the Charles Sturt University wine industry course advisory committee.

Michael Roach is a committee member (webmaster and promotions) of the Adelaide Protein Group – a special interest group of the Australian Society for Biochemistry and Molecular Biology and a member of the Australian Bioinformatics and Computational Biology Society.

Ella Robinson is a member of the Australian Wine Industry Technical Conference Planning Committee.

Neil Scrimgeour is the chair of the planning committee for Crush – the grape and wine science symposium.

Con Simos is Chair of the National Wine Research and Extension Network (to December 2018); board member of Wine Communicators of Australia (to March 2019); member of the Australian Wine Industry Technical Conference Planning Committee; member of the Wine Strategy Implementation Committee; member of the WA Wine Industry Association R&D Committee; and graduate of the Australian Wine Industry Future Leaders Program.

Creina Stockley is an Affiliate Senior Lecturer at the University of Adelaide. She is a member of the Wine Industry Technical Advisory Committee. She is a delegate and expert for the Organisation Internationale de la Vigne et du Vin. She is also an Associate Editor of *OENO One*, and a member of the editorial board of the *International Journal of Wine Research*, *International Journal of Food and Fermentation Technology*, *Austin Journal of Cardiovascular Disease and Atherosclerosis*, *Journal of Nutritional Therapeutics* and *Journal of Wine Research*, as well as a charter member of the International Scientific Forum on Alcohol Research, a member of the Advisory Board of the Paralelo 40 International Surveillance System on Mediterranean Diet (Spain), a member of the Scientific Board and Scientific Council of Experts of the (European) Wine Information Council, and a member of the European Food Safety Authority Expert Database. Creina is also a member of the Scientific Committee for the WineHealth 2019 International Wine and Health Conference.

Cristian Varela is a member of the Editorial Board of the journals *Applied and Environmental Microbiology, International Journal of Food Microbiology* and *Food Microbiology*. He is also Affiliate Senior Lecturer at the University of Adelaide and member of the Australian Society of Viticulture and Oenology.

Matthew Wheal is the Secretary and South Australian representative of the Australasian Plant and Soil Analysis Council.

Eric Wilkes is the Chair of the Interwinery Analysis Group committee and a member of the FIVS (International Federation of Wines and Spirits) Scientific and Technical Committee. He chairs the APEC Wine Regulatory Forum Enhanced Risk Controls Working Group and is a member of the International Wine Technical Summit working groups on Authenticity and Counterfeit, Analytical Method Quality, Laboratory Quality and Expression of Limits.

Project reports

Customers, consumers and markets

The Australian wine industry depends on producing wines that consumers value, trust and are able to access in both domestic and international markets. Projects under this theme aim to take a scientific approach to understanding consumer preferences; to inform consumers about health and safety impacts of wine consumption; to provide technical guidance on agrochemical use to meet export market requirements; to provide support for market promotion activities; to preserve the integrity and quality of Australian wine; and to contribute technical expertise to national and international forums on wine regulation.

Staff

Francesca Blefari, Geoff Cowey, Marcel Essling, Peter Godden, Prof. Markus Herderich, Matt Holdstock, Anne Lord, Elli-Marie Panagis, Wes Pearson, Virginia Phillips, Con Simos, Dr Creina Stockley (to 21 December 2018), Dr Eric Wilkes.

Collaborators

Accolade Wines (Jonathan Breach); Agrochemicals Reference Group; agrochemical manufacturers, suppliers and consultants; AgVet Chemical Forum (Janine Clark); Australian Grape & Wine (AGW) (Tony Battaglene, Damien Griffante); Australian Pesticides and Veterinary Medicines Authority (APVMA) (Jason Lutze, Ken Robinson); CropLife Australia (Katie Asplin); Department of Agriculture (Nigel Pinto); E. & J. Gallo Winery, USA (Steve Tallman); ETS Laboratories, USA (Gordon Burns); FIVS (Dr Greg Hodson, Bennett Caplan); Food Standards Australia New Zealand (FSANZ) (Dr Mark FitzRoy); GrapeLink (Graeme Forsythe); Grapeweb (Mark Riddell, Mark Roberts); Homologa (Janika Schuster); Institute of Masters of Wine, UK (Olivier Chapman); Organisation International de la Vigne et du Vin (OIV), France (Jean-Marie Aurand, Dr Jean-Claude Ruf); South Australian Research and Development Institute (SARDI) (Barbara Hall); Treasury Wine Estates (Mandy Gerhardy); Wine Australia (Steve Guy, Laura Jewell, Ali Lockwood, Rachel Triggs); Wine Institute, USA (Katherine Bedard).

Informing government, producers and consumers about health and safety aspects of wine

Background

The aim of this project was to disseminate knowledge of the effects of alcohol consumption on human health and society.

Provision of scientific information

A number of technical and briefing papers were prepared for the AWRI's stakeholders. Topics covered included:

- the potential impact of minimum unit pricing on alcohol consumption and specifically harmful alcohol consumption
- price elasticity for alcoholic beverages in Australia
- the relationship between alcohol and cognitive function
- public information on 'no safe level' of alcohol
- associations between alcohol consumption and cancer risk.

In addition, information requests from stakeholders relating to alcohol and health were addressed on topics including: the j-shaped relationship between alcohol consumption and coronary/ischaemic heart disease, diabetes and ischaemic stroke as well as alcohol-attributable cancers and other alcohol-attributable diseases; allergic reactions from biogenic amines, sulfites, and proteinaceous fining agents in wine; and effectiveness of pregnancy warning labelling. Peer-reviewed papers were also reviewed for inclusion in the AWRI's bi-monthly publication *Technical Review*.

Supporting market access, safety and regulation

Background

Maintaining market access or opening markets for Australian wine, nationally and internationally, is facilitated by managing and reducing current and potential barriers to trade. The Australian wine industry needs to anticipate, facilitate and influence regulation of wine composition, production, labelling and marketing. This project provides regulatory-related scientific and technical advice and assistance for the activities of key industry stakeholders. In addition, representation at national and international industry forums raises awareness of matters of concern to the Australian wine industry.

Peter Godden

Supporting export of Australian wines

Scientific and technical advice and assistance were provided to the Australian wine industry on a range of market access issues. These included changes to European limits for certain fungicides and the herbicide glyphosate. Analysis of residues in Australian wine show that early action by the Australian industry has helped limit the impact of the European ban on iprodione, with the number of wines found with residues above the limit of quantification rapidly decreasing with each vintage, dropping from 25% of surveyed wines in 2016 to less than 3% in 2018. Chlorothalonil has not been detected in any wines since vintage 2016. Glyphosate levels were also below the Australian maximum residue limits (MRLs) for all surveyed wines, with work continuing to understand the impacts of any changes to MRLs in other markets.

The team continued active participation in forums including the International Wine Technical Summit, FIVS, World Wine Trade Group, the OIV and the APEC Wine Regulatory Forum as well as supporting the Wine Industry Technical Advisory Committee to understand changes to the international regulatory environment and to support improved market access. At the OIV Prof. Markus Herderich was elected to chair the subcommission for analytical methods. Members of this subcommittee aim to harmonise and validate analytical methods, working towards global recognition by regulatory and industry laboratories.

Papers and presentations prepared during the year covered:

- recommendations on the international harmonisation of sugar measurement in wines
- a proposal that analytical results from ISO17025 (NATA equivalent) laboratories be accepted in all APEC destination markets
- issues associated with regulatory limits on methanol, titratable acidity and sugar free extract being applied to ensure the safety, quality or authenticity of wines.

The project team also had significant involvement in helping to address issues arising from changing regulatory requirements in some destination markets, including new analytical requirements from the Thai and Brazilian Governments and an emerging issue of certification of the absence of water additions for wine exported to Uruguay and Brazil.

The international ring test program managed by the AWRI in conjunction with the Interwinery Analysis Group continued to be successful in aligning the analytical capabilities of a range of APEC nations who import and export wine, helping to reduce incidents of wine being rejected in market due to failure to meet analytical requirements. In 2019 the program was supported by the Wine Institute, USA to ensure its continuation following the end of the APEC program. Plans are in place for the 2020 program to be expanded to more than twenty countries, including emerging wine importers in Africa, India and South America, using funding secured from the Australian Government by AGW. It is hoped that this will continue to reduce the occurrence of mismatched analytical results between importing and exporting countries.

Enhancing the reputation of Australian wine through market promotion activities

Background

This project supports Wine Australia's market development strategy by providing targeted technical content designed to inform and educate the wine trade, media and consumers. An engaging message creates opportunities to promote the innovation dimension of Australian wine. Under this project, the AWRI hosts and delivers presentations to international visitors and presents themed tastings, masterclasses and educational activities at Wine Australia events.

Geoff Cowey

Market promotion activities

Presentations were delivered at events in Australia, Austria, Germany and the United Kingdom. A one-day wine judging course for 16 Institute of Masters of Wine students was presented in Adelaide in November 2018. The Aroma Wall was presented in London in January 2019.

Collecting and disseminating information on agrochemicals

Background

Governments around the world monitor residues of agrochemicals and set limits for the amounts that are legally allowed in foods, including grapes and wine. Up-to-date information on agrochemical management is needed to ensure that finished wines meet these limits and do not encounter trade barriers. This project aims to assist grape and wine producers to manage agrochemical residue levels in their products. This is achieved by collating and providing accurate and timely information on regulatory and technical aspects of chemicals registered for use in Australian viticulture and the MRL requirements of those chemicals in domestic and key export markets.

Keeping up with a changing regulatory environment

The project team reviewed 188 Sanitary and Phytosanitary notifications from the World Trade Organization and 27 gazettes issued by the APVMA. These reviews highlighted changes to MRLs for markets including Japan, the European Union and Canada. The APVMA gazettes raised issues such as the registration of new active constituents including mefentrifluconazole, a fungicide that specifically targets powdery mildew in grapes.

Each year, post-harvest, the project team reviews the latest information on agrochemicals by liaising with regulators, chemical manufacturers, suppliers and end-users. Best practice recommendations are then incorporated into a new version of the publication *Agrochemicals registered for use in Australian viticulture* (commonly known as the 'Dog book'). More than 8,500 copies of the 2019/2020 'Dog book' were produced and distributed in June 2019. Updates were made to the online search portal and the smart phone agrochemical app, and an electronic version of the 'Dog book' was made available through the AWRI website.

Three new active constituents were registered for wine-grape production: acetamiprid, pyriproxyfen and mefentrifluconazole. Sensory analysis and residue data were reviewed to assess the suitability of these constituents for use in wine production and to establish withholding periods for wines destined for export.

To avert the risk of downy mildew causing crop loss, an application was made to the APVMA to allow grapegrowers access to products containing metalaxyl that were not registered for use with grapes. An emergency use permit was granted in December 2018. Eight agrochemical or pest and disease-related *eBulletins* were issued during the year including a notification about the emergency permit for metalaxyl-containing products and advice on a permit allowing the use of fipronil for wasp control.

Extension, adoption and education

The full value of research and development is only realised in industry when outcomes are effectively and efficiently implemented by practitioners. For this to occur, both extension and support for adoption are required. Projects under this theme apply a range of proven mechanisms to communicate research outcomes, solve industry problems, provide access to relevant technical resources, educate and train students, foster industry adoption and bridge gaps between research and practice.

Staff

Tadro Abbott (to 12 April 2019), Gayle Baldock, Linda Bevin, Francesca Blefari, Maria Calabrese (to 7 July 2018), Adrian Coulter, Geoff Cowey, Michael Downie, Marcel Essling, Cini Gapper (to 7 February 2019), Peter Godden, Dr Yoji Hayasaka, Prof. Markus Herderich, Tony Hoare (from 13 August 2018), Matt Holdstock, Dr Mark Krstic, Dr Mardi Longbottom, Anne Lord, Dr Simon Nordestgaard, Elli-Marie Panagis, Dr Paul Petrie (to 30 November 2018), Virginia Phillips, Ella Robinson, Jessica Scudds (from 1 April 2019), Con Simos, Dr Creina Stockley (to 21 December 2018), Randell Taylor, Dr Eric Wilkes.

Collaborators

Agriculture Victoria (Dr Sze Flett, Dr Tim Plozza); Barossa Grape & Wine Association (Nicki Robbins); Brown Family Wine Group (Brett McClen); Department of Primary Industries NSW (Adrian Englefield, Darren Fahey); Hoddles Creek Estate (Franco D'Anna); Langhorne Creek Wine Region (Lian Jaensch); Limestone Coast Grape and Wine Council (Dr Kerry DeGaris, Ulrich Grey-Smith); Mornington Peninsula Vignerons Association (Olivia Barrie, Cheryl Lee, Tyson Lewis); Mount Langi Ghiran (Damien Sheehan); Murray Valley Winegrowers (Paul Derrico, Mike Stone); NSW Wine Industry Association (Angus Barnes, Liz Riley); OICCE Times-Rivista di Enologia, Italy (Dr Giusi Mainardi); Practical Winery and Vineyard Journal, USA (Don Neel); Queensland Wine Industry Association (Mike Hayes); Riverland Wine (Chris Bennett, Chris Byrne); state and regional wine industry associations; University of Melbourne (Prof. Snow Barlow, Dr Pangzhen Zhang); WBM (Anthony Madigan); Western Australian Department of Primary Industries and Regional Development (Richard Fennessy); Wine Australia (Hannah Bentley, Belinda Bramley, Jo Hargreaves, Dr Sharon Harvey, Ali Lockwood, Dr Paul Smith, Jacquie van Santen, Dr Liz Waters); Wine Communicators of Australia (WCA) (Lynda Schenk); Wine Grapes Marketing Board (Brian Simpson); Wine Network Consulting (Mark O'Callaghan, Rachel Sutcliffe); Wines of Western Australia (Larry Jorgensen); Wine Tasmania (Paul Smart); Wine Victoria (Angie Bradbury, Damien Sheehan, Rachael Sweeney); Winetitles (Eleanor Danenberg, Sonya Logan, Hans Mick); Yarra Valley Wine Growers Association (Caroline Evans, Susanne Pyle); Yering Station (Willy Lunn, Darren Rathbone).

The staging and conduct of extension programs

Background

The AWRI's extension program aims to facilitate the early awareness of research findings, technology adoption and practice change, all of which contribute to improvements in competitiveness. Activities include the long-standing roadshow seminar program, practical workshops, webinars, the Research to Practice program, the Advanced Wine Assessment Course and other tasting events. Additional education activities in areas not covered by levy-payer-funded extension are delivered under a user-pays model. Having a number of different platforms for the extension of technical information is important as it helps cater for diverse audiences and provides different ways for messages to be delivered.

Roadshow seminars and workshops

During the year, 17 roadshow seminars and 33 workshops were held in winemaking regions across Australia (see Appendix 2 for details). Workshop topics included spray application, addressing regional challenges, Shiraz and Cabernet Sauvignon winemaking treatment tastings and smoke taint. A total of 1,223 participants attended these events in 2018/2019.

Extension survey

During the year the AWRI commissioned First Person Consulting to survey people who had attended AWRI extension events to understand the level of adoption and practice change occurring based on the content presented. The survey covered all the AWRI's extension events including the roadshow seminars and workshops and the more recent winemaking treatment workshops which have been held over three consecutive vintages.

The winemaking treatment workshops were very popular, attracting more than 600 attendees over the past three years, with many positive testimonials collected from these events. Of the people who had attended one of these tasting events, 58% indicated they had changed a practice based on information they had seen presented at that workshop. Further survey data showed that of people who attended an AWRI seminar or workshop, 82% of respondents had adopted a new practice or changed their existing practices.

Webinars

Fifteen webinars were presented to a total of 610 attendees in 2018/2019. Webinar recordings were viewed more than 9,500 times on the AWRI's YouTube channel, almost three times more than the previous year. Webinars covered a wide spectrum of topics with a focus on viticulture this year, including biosecurity, vine balance, salinity, antitranspirants, trunk disease, water management and climate forecasting. The portfolio of presenters was equally diverse, with just one-quarter of all sessions presented by AWRI staff.

Educational courses and events

Three Advanced Wine Assessment Courses were held at the AWRI during the year, with 16 participants in each course. An abridged course was delivered for the Barossa Grape & Wine Association in May 2019. At each tasting course, participants used the ShowRunner software platform. The project team was also involved in presenting a range of other events including viticulture content and sensory masterclasses and delivered a number of lectures and presentations (see Appendix 2).

Support for Wine Communicators of Australia

The AWRI provided technical support and hosting for 11 WCA webinars and continued to enhance and support the WCA website.

Communication with stakeholders

Background

Communication with the Australian grape and wine community is an essential aspect of the AWRI's activities, helping to maximise benefits from investments in research, development and extension by promoting awareness and adoption. This project develops new content and manages the delivery of information and knowledge to Australian grape and wine producers in formats designed for easy understanding and practical adoption. Communication outlets include the AWRI website, industry journals, the AWRI Annual Report, *Technical Review*, electronic newsletters and social media. Details of all presentations delivered and articles published by AWRI staff in 2018/2019 are listed in the Appendices.

AWRI website

The AWRI website is a major platform for communicating with grape and wine producers, students, potential employees and the general public. Approximately 150,988 visitors (23.1% increase from 2017/2018) accessed the AWRI website during the year, with more than 540,076 page-views. Of the total page-views, 32% were viewed using a mobile device or tablet. Updates to content included new fact sheets, summaries of the projects being conducted under the AWRI's 2017-2025 RDE plan, information about the AWRI wine microorganism culture collection, and a large number of previously published columns and articles. The website was also used to communicate with levy payers about the AWRI Board election and to promote events including seminars, workshops, tastings and webinars.

eBulletins and *eNews*

Twenty-one *eBulletins* were delivered to approximately 3,350 subscribers during the year (Table 1).

Table 1. *eBulletins* issued during 2018/2019

Date	Topic
4/07/2018	Agrochemical update – new insecticide registered
7/08/2018	Managing dry winter conditions
9/08/2018	*Technical Review* August 2018 issue available
21/08/2018	Five new AWRI webinars – registration is open now!
4/09/2018	Safe spray application reminder
10/09/2018	Implications of fumigation and heat treatment on imported oak barrels and other products
5/10/2018	Six new AWRI webinars – registration is open now!
15/10/2018	*Technical Review* October 2018 issue available
7/11/2018	Downy mildew – webinar and key management steps
13/12/2018	*Technical Review* December 2018 issue available
19/12/2018	Agrochemical update – emergency use permit for metalaxyl/metalaxyl-M products
19/12/2018	Christmas closure
13/02/2019	Agrochemical update – wasp control permit
14/02/2019	*Technical Review* February 2019 issue available
12/04/2019	*Technical Review* April 2019 issue available
29/04/2019	Bright future for sustainability of Australian wine
30/05/2019	Vineyard and winery practices report
13/06/2019	*Technical Review* June 2019 issue available
18/06/2019	Agrochemical update – new 'Dog book' available
20/06/2019	Agrochemical update – change to EU MRL for iprodione
26/06/2019	Agrochemical update – new fungicide registered

The AWRI's electronic newsletter, *eNews*, was distributed bi-monthly to an audience of more than 3,600 subscribers. This publication provides information about upcoming events, new information resources, research updates and a general snapshot of the AWRI's activities.

Social media

The AWRI's Twitter following grew by over 120 during 2018/2019 to reach 3,515. The AWRI's Facebook presence also grew by almost 250 likes during the year to reach 1,250. The AWRI's YouTube channel includes AWRI webinar recordings and other AWRI video content. Subscribers grew by more than 200 during 2018/2019 and the channel attracted more than 9,500 views.

Annual report

For the past 64 years, the AWRI has produced a printed annual report as its formal report to Australian winemakers and grapegrowers. Since 1999, the annual reports have also been made available on the AWRI's website. The AWRI publishes a summary of the annual report in the *Australian & New Zealand Grapegrower & Winemaker* and offers to deliver an annual presentation to the board or executive of each major state-based winemaking body. This formal activity complements the wide range of other extension and communication activities undertaken by AWRI staff members throughout the year (see Appendices).

Technical Review

The AWRI's bi-monthly publication, *Technical Review*, publishes abstracts of recently published grape and wine science literature and technical articles authored by AWRI staff. *Technical Review* is available to grape and wine producers via the AWRI website or in hard copy. A total of 598 articles featured in the *Technical Review* Current Literature section were requested by and provided to readers during the year.

Editorial support

The AWRI contributes regular articles to *Wine & Viticulture Journal* and *Australian & New Zealand Grapegrower & Winemaker*, while also contributing to other Australian and international industry journals. Details of the articles published are included in Appendix 7.

Media liaison

The AWRI is regularly approached by national and international media for comment on technical issues related to wine. One media release was prepared and distributed and 44 requests from the media were handled during the year (Appendix 6).

Development of digital extension tools and software

Background

The AWRI currently provides a range of online databases and mobile apps to support Australian grape and wine producers. The uptake of these technologies is high and the demand for technology to improve productivity or promote efficient processes will continue to increase. This project ensures there is a planned and coordinated approach to the development, delivery and maintenance of innovative and collaborative digital tools.

Agrochemical and MRL database platforms

The Agrochemical and MRL databases form the core capability behind the 'Dog book', agrochemical and MRL online search functions and agrochemical mobile apps. Redevelopment of the agrochemical and MRL database platforms commenced during the year with a new cloud-based data administration portal and new search portal to be launched in early 2019/2020. The agrochemical mobile app has undergone a major upgrade with a new MRL search function added.

Query investigation system

The helpdesk and investigative service is managed using a desktop application MySQL database developed in 2011 and enhanced in 2018/2019 to allow for a paperless support service operation. The database now has 37 active AWRI users, 62 historical users and contains entries for 8,000 companies, 17,000 industry contacts and 52,000 historical queries. In 2019/2020 a project exploring the development of an online helpdesk platform will commence.

ShowRunner

Background

ShowRunner is an all-in-one wine show management system developed at the AWRI, which covers all aspects of a wine show from online entries to electronic scoring and production of results. The software began as a tailored solution for the Advanced Wine Assessment Course and has been adapted to the processes and practices of the Australian wine show system.

Adoption by Australian wine shows

During the 2018 wine show season 31 shows used the ShowRunner platform, including the National Wine Show of Australia. A software and support licence agreement was implemented for all clients in 2018 and will continue to be used for all future clients. An extra module has been developed which allows wineries and winemakers to use a modified version of ShowRunner as an internal grading and classification tool for wines.

Regional engagement – the AWRI Victorian node

Background

The AWRI's Victorian node delivers high-quality extension and practice change services to Victorian wine-grape growers and wineries through a partnership between Wine Victoria, Murray Valley Winegrowers, Wine Australia, Agriculture Victoria and the AWRI. Project activities are overseen by a Victorian Winegrowers Liaison Committee, which agrees on an annual workplan of activities under funding from Agriculture Victoria and Wine Australia's Regional Program.

Node activities

Key extension activities in 2018/2019 included evaluation of a rootstock demonstration trial and associated seminar in the Mornington Peninsula, integrated pest management workshops, soft pruning workshops, tastings from the AWRI's Cabernet Sauvignon winemaking trial and sessions on smoke taint. The AWRI finalised a business plan in collaboration with Wine Victoria for future funding between 2019 and 2023, focusing on four key priorities: climate change, premiumisation and productivity, biosecurity and smoke taint.

AWRI helpdesk

Background

The AWRI's technical helpdesk plays an important role supporting grapegrowers and winemakers across Australia. The helpdesk provides rapid, confidential, technical support on topics across winemaking and viticulture, delivered by an experienced multi-disciplinary team.

Helpdesk enquiries

During 2018/2019, 1,959 enquiries were received (Table 2). This is approximately 200 more queries than the past few years but similar to numbers received in other hot seasons with bushfire events. Increases were seen across both wine and viticulture topics (Figure 1). The majority of the enquiries were from grape and wine companies and suppliers actively aligned with the wine industry, with a small number coming from government organisations, students, legal practitioners and journalists. Figure 2 shows that the sources of enquiries were in line with the proportional volume of wine-grape plantings for each state/territory.

Table 2. Enquiries received by the AWRI helpdesk in 2018/2019

Topic	Number of enquiries
Winemaking	1,423
Viticulture	536
Total	**1,959**

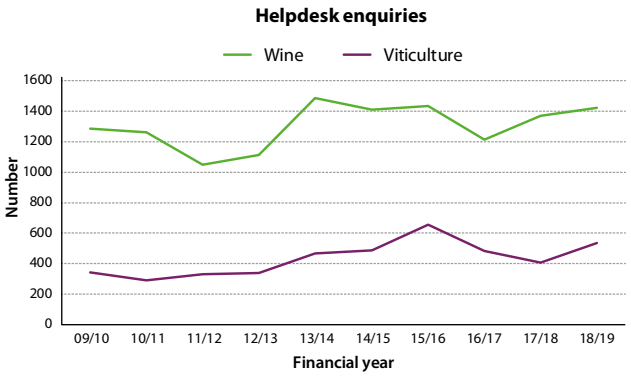


Figure 1. Number of viticulture and winemaking enquiries received by the AWRI helpdesk over the past ten financial years

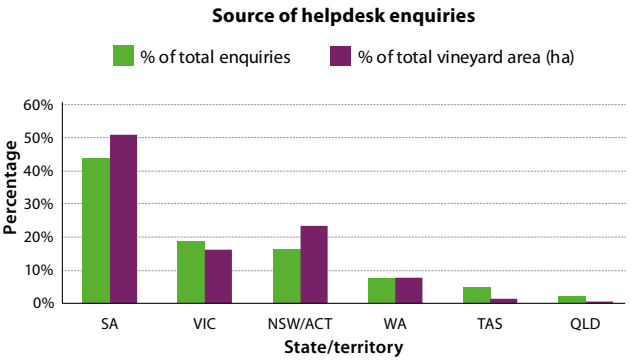


Figure 2. Enquiries received by the AWRI helpdesk in 2018/2019 by state/territory compared to wine-grape vineyard area in 2018 (Wine Australia National Vineyard Scan 2018)

Helpdesk enquiries are classified using 22 different keywords. The number of each query type is compared to historical monthly levels that have been collected over more than 20 years, to help identify national, state and regional trends. This allows for prompt responses to emerging issues and timely provision of relevant information. Figure 3 shows the queries arranged from most to least used keyword, highlighting key events or issues that occurred across 2018/2019.

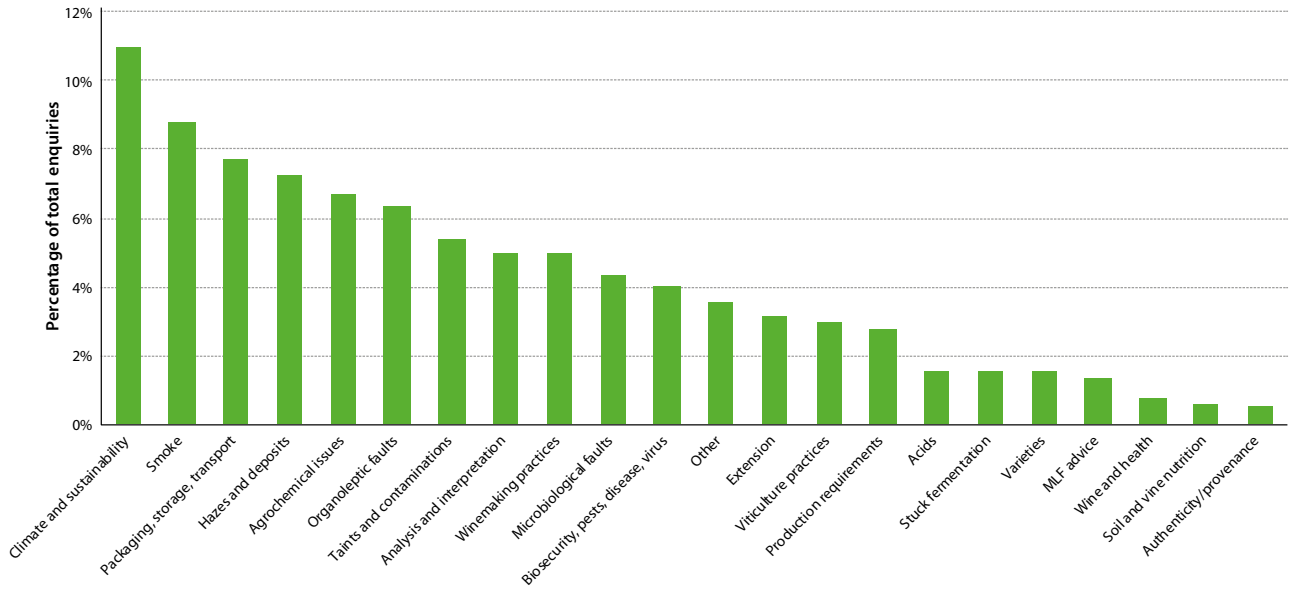


Figure 3. Enquiries received by the AWRI helpdesk in 2018/2019, organised by frequently used keywords. Enquiry numbers are represented as a percentage of total national enquiries.

Viticultural enquiries

During the year, the viticulture team responded to 536 viticulture-related enquiries, with the largest proportion on climate and sustainability. Climate queries covered the challenging weather encountered during the growing season and vintage. Other key issues included concerns about increased prevalence of grapevine virus A and leafroll virus in some regions and requests for help identifying possible brown marmorated stink bug (BMSB) insects. Restrictions on residues of iprodione were another priority for growers.

Winemaking enquiries

The largest number of winemaking queries received this season were on smoke taint, with bushfires occurring across six states. The helpdesk worked with regional associations to coordinate smoke taint Q&A events and implemented centralised sample submission for smoke taint analysis. The helpdesk team interpreted approximately 300 smoke taint analysis results. A review was held with key producers at the end of the season to identify any improvements that could be made to the AWRI's analysis and support during smoke taint events.

Other key topics for winemaking enquiries included hydraulic oil contaminations, unexpected alcohol levels, water additions to high sugar musts and the implications of fumigation and heat treatments on shipments of imported oak barrels and glass bottles as part of biosecurity efforts to prevent an incursion of BMSB.

Winemaking problem-solving investigations

Approximately 16% of winemaking enquiries resulted in investigations, with samples requested and analysis performed to identify the problem and recommend a solution. The helpdesk team conducted 222 problem-solving investigations on 975 samples (Table 3), consistent with previous years. As for enquiries, use of the problem-solving investigative service was in line with the proportional volume of wine-grape plantings for each state/territory (Figure 4).

Table 3. Winemaking investigations conducted and samples analysed by the AWRI helpdesk in 2018/2019

Type of investigation	2018/2019
Hazes and deposits	60
Microbiological issues	42
Sensory investigations	44
Taints and contaminations	42
Other investigative analyses	33
Closure-related investigations	1
Total number of investigations	**222**
Total number of samples analysed	**975**

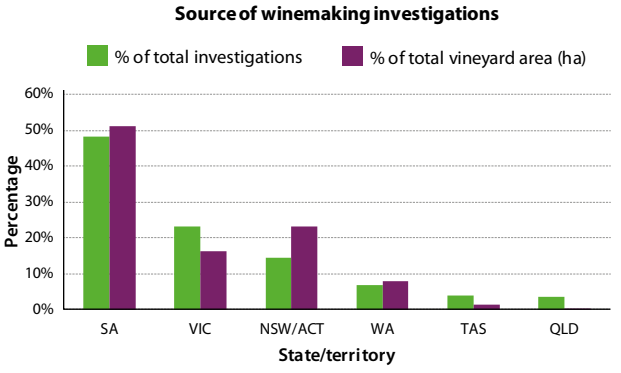


Figure 4. Winemaking investigations undertaken by the AWRI helpdesk in 2018/2019 by state/territory, compared to wine-grape area in 2018 (Wine Australia National Vineyard Scan 2018)

Winemaking investigations are assigned to five main categories: hazes and deposits, sensory investigations, microbiological issues, taints and contaminations, and other. The proportion of investigations in each category has remained relatively consistent over the last ten years, with approximately 20% in each category (Figure 5).

Closures is an additional category where investigations were common in the past; however, investigations in this category are now rare because of the widespread uptake in Australia of non-cork-based closures.

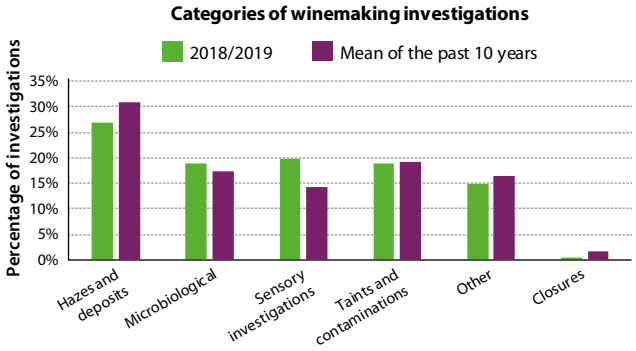


Figure 5. Winemaking investigations approximately equally spread across five main categories

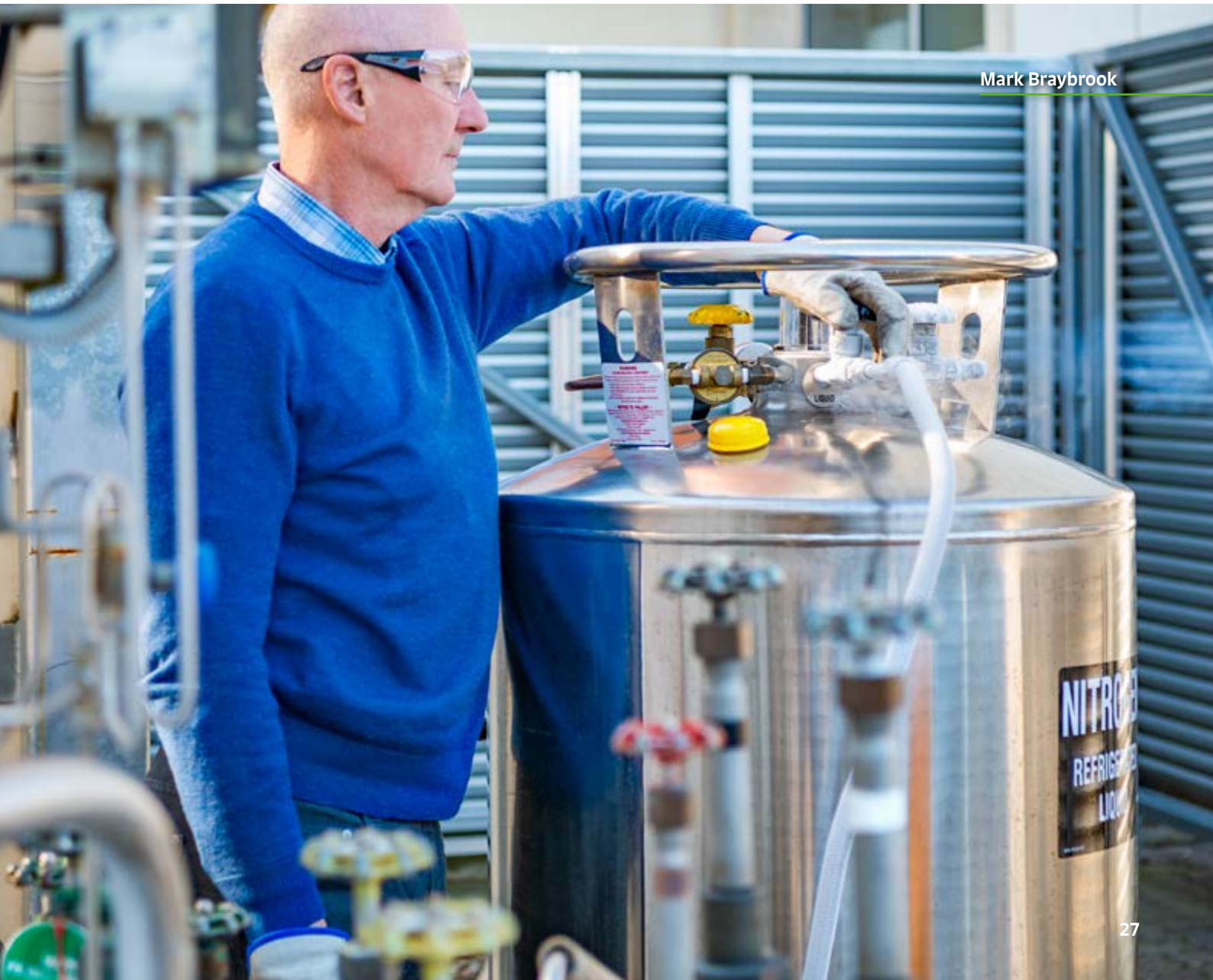
Hazes and deposits

One-third of the hazes and deposits identified in 2018/2019 were crystalline, with half of these being identified as calcium tartrate or calcium DL tartrate. These deposits generally only form in wines with elevated calcium concentrations, historically only in cooler climates; however, several warm inland regions were found to have elevated calcium levels in their wines this year. Additionally, calcium DL tartrates only form if racemic DL tartaric acid or potassium hydrogen tartrate have been used in wine processing. These products are generally cheaper than the natural L isomers, and are legally allowed additives, but increase the risk of calcium instabilities.

Microbiological issues

Half of the microbiological investigations conducted in 2018/2019 concerned *Brettanomyces* spoilage or 'mousy' off-flavour. The prevalence of 'mousy' off-flavour issues reported to the helpdesk continues to increase across both white and red wines. A new method for analysis of 'mousy' compounds developed this year has allowed analysis to be used to aid in diagnosis rather than having to rely on tasters who are sensitive to the character.

Six wine companies are facing ongoing issues relating to growth of black 'mould' on the exterior of outdoor wine tanks and walls. The 'mould' does not appear to be the same across different companies. Three types of 'mould' were identified: *Exophiala, Cladosporium* and lichen. None of the 'moulds' were the same as the black 'mould' *Baudoinia compniacensis* reported in literature as having been found in distilleries, which has made development of a standard treatment recommendation difficult. A project investigating the growth of black 'mould' on winery tanks will commence in 2019/2020.



Sensory investigations

Sensory issues investigated by the helpdesk are often related to oxidation or sulfide development. Examples included premature oxidation of packaged wine, greater sulfur dioxide loss than expected in-bottle due to microbiological growth in 'minimal filtration' wines, filtration failures, and poor bottling line gas management. Sulfide faults were also prominent this year, resulting in increased investigations under the 'sensory' category (Figure 6). Several producers successfully treated sulfide faults using copper followed by fining with polyvinylimidazole-polyvinylpyrrolidone (PVI/PVP) to remove excess copper and copper-sulfide complexes.

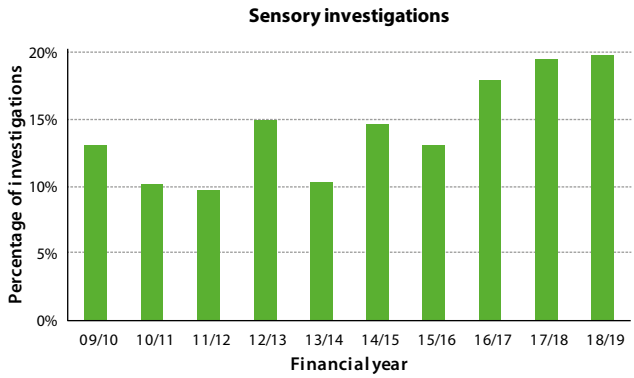


Figure 6. Sensory-related investigations conducted by the AWRI helpdesk from 2009/2010 to 2018/2019

Taints and contaminations

Around one-fifth of investigations of taints and contaminations this year involved analysing grapes, musts and wines for evidence of hydraulic oil contamination. A further segment included investigations examining the sensory relationships between smoke-affected fruit and wine made from the fruit, given the lack of sensory threshold information correlating smoke taint marker compounds and perception of smoke taint by tasters. There were also a large number of unbottled wines with 'musty' taints. These were found to be evenly split between trichloroanisole (TCA) and tribromoanisole (TBA).

Library services

Background

The John Fornachon Memorial Library develops and maintains a major collection of historical and current print and digital resources and offers a range of information discovery tools and services. The library supports the Australian grape and wine sector by providing timely responses to technical and scientific information enquiries.

Online catalogue

The library's new online catalogue was released to industry in June 2019. This platform provides a fully featured, adaptable and future-proofed library system and delivers significant improvements in user experience as well as collection accessibility and discoverability.

eBook collection

The library continued to prioritise investment in eBooks in 2018/2019, with the collection growing to more than 160 titles. Access to titles was streamlined via integration with the library's new online catalogue.

Staff publications database

The staff publications database, accessible via the AWRI website, received more than 6,100 hits this year with 815 staff publications requested and delivered. This collection contains more than 2,100 AWRI-authored publications and is updated regularly to ensure the latest publications are available.

Online information packs

Online information packs are collections of handpicked references focused on a single relevant issue. These resources assist growers and winemakers to easily discover topical resources and provide a streamlined option for retrieval of valuable information. The website received 1,480 hits on information packs during the year and delivered more than 530 articles from information packs.

Library reference and information requests

The library responded to 885 reference and information requests resulting in supply of 1,907 articles (Table 4). More than 90% of the requests were completed within one business day and over 90% of the requests were received via the AWRI website or other electronic means. Library staff also conducted 64 specialised literature searches on a variety of topics including winemaking, vineyard management, winery operations, pest and disease management and wine and health.

Table 4. Articles supplied from library collections in 2018/2019

Article type	Number of articles supplied
AWRI staff publications	815
Technical Review Current Literature	598
Library reprint collection	494
Total	**1,907**

Regional Program

Background

The AWRI coordinates Wine Australia's Regional Program, which supports the regional extension and adoption of research and development findings in the Australian grape and wine sector. The program provides an important connection between relevant research and development and locally identified grapegrower and winemaker needs. Funding from Wine Australia is provided to 11 Regional Program partners, who develop, deliver and report on activities completed within the Regional Program.

Regional activities

The AWRI assisted in coordinating the design and delivery of extension and adoption activities within the program's 11 regions via input into each region's Annual Operating Plan. The annual regional partners meeting was held in Stanthorpe, Queensland in July 2018, with updates from the 11 regional partners and discussions on alternative varieties, soft pruning and pest and disease management workshop collaboration opportunities. The Regional Program also supported the implementation of Wine Australia's Incubator Initiative, a program which supports early career researchers spending time in wine regions to conduct R&D activities.

Performance, products and processes

There are numerous processes involved in wine production, from grapegrowing through to delivery of finished product to consumers. Projects under this theme aim to optimise these processes and reduce costs, resulting in overall improvements to wine quality and business sustainability. Specific areas include target setting and objective measures for grape quality and wine style; optimisation of primary and secondary fermentation; assessing new winery processes and equipment; preventing and treating taints and faults; and achieving a greater understanding of wine flavour and texture.

Staff

Melissa Aitchison (from January 2019), Vicky Amora (to 8 August 2018), Gayle Baldock, Caroline Bartel, Sheridan Barter, Dr Marlize Bekker, Dr Jenny Bellon, Laura Bey, Eleanor Bilogrevic, Dr Keren Bindon, Dr Anthony Borneman, Dr Peter Costello, Adrian Coulter, Geoff Cowey, Kate Cuijvers, Dr Julie Culbert, Dr Bob Dambergs, Dr Martin Day, Simon Dillon, Damian Espinase Nandorfy, Angus Forgan, Dr Leigh Francis, Dr Toni Garcia Cordente, Dr Richard Gawel, Yevgeniya Grebneva, Dr Yoji Hayasaka, Prof. Markus Herderich, Kieran Hirlam, Dr Josh Hixson, WenWen Jiang, Charlotte Jordans, Stella Kassara, Radka Kolouchova, Dr Mark Krstic, Allie Kulcsar, Dr Darek Kutyna, Desireé Likos (from 14 January 2019), Jane McCarthy, Dr Jacqui McRae (to 28 June 2019), Dr Agnieszka Mierczynska-Vasilev, Dr Simon Nordestgaard, Dr Cristobal Onetto, Mango Parker, Wes Pearson, Dr Paul Petrie (to 30 November 2018), Lisa Pisaniello, Song (Luke) Qi (from 5 November 2018), Tim Reilly, Mark Rullo (from 5 July 2018), Dr Simon Schmidt, Alex Schulkin, Neil Scrimgeour, Dr Tracey Siebert, Mark Solomon, Dr Cristian Varela, Flynn Watson (from 17 September 2018), Dr Eric Wilkes, Dr Patricia Williamson (to 12 November 2018).

Students

Eva (Yihe) Sui (University of Adelaide), Lisa Hartmann (University of Adelaide), Jana Hildebrandt (University of South Australia), Lin Sun (University of Adelaide), Colleen Szeto (University of Adelaide).

Visiting students

Lidia Delgado (University of Nottingham, UK), Kristina Nobis (Technical University of Dresden, Germany), Elia Romanini (Università Cattolica del Sacro Cuore, Italy), Louisa Schueth (Technical University of Dresden, Germany).

Visiting researchers

Dr Felipe Laurie (Universidad de Talca, Chile), Dr Bo Teng (Sichuan University, China).

Collaborators

Accolade Wines (Warren Birchmore, Lucy Clements, Paul Easton, Alex Sas); Agriculture Victoria (Joanne Bui, Dr Tim Plozza, Pei Zhang); Ball Corporation, USA (Brent Trela); Brown Family Wine Group (Geoff Alexander, Joel Tilbrook); Cape Jaffa Wines (Anna Hooper); Constellation Wines, USA (Martin Di Salvo, Chris Hartless, John Thorngate); CSIRO (Dr Paul Boss, Dr Rob Bramley, Peter Clingeleffer); De Bortoli Wines (Steve Webber); E. & J. Gallo Winery, USA (Steve Tallman); Flinders University (Dr Martin Johnston); Henschke Wines (Prue Henschke); Hochschule Geisenheim University, Germany (Dr Simone Mueller-Loose, Prof. Doris Rauhut, Prof. Manfred Stoll); Indonesian Institute of Sciences (Dr Satriyo Wahono); Institute of General and Ecological Chemistry, Lodz University of Technology, Poland (Dr Waldemar Maniukiewicz, Dr Pawel Mierczynski); Dr John Danilewicz; La Trobe University (Dr Ian Porter); Macquarie University (Prof. Sakkie Pretorius); Mondelez International (Dr Gal Kreitman); Mount Langi Ghiran (Damien Sheehan); Mount Majura Vineyard (Dr Frank van de Loo); National Wine and Grape Industry Centre, Charles Sturt University (Dr Andrew Clark, Dr Nicos Kontoudakis, Prof. Leigh Schmidtke, Prof. Geoff Scollary); Northwest Agriculture and Forestry University, China (Dr Anque Guo); Oregon State University, USA (Dr Chris Curtin); Orora Beverage (Kane Chandler); Pernod Ricard Winemakers (Brock Harrison, Ryan Haynes, Kate Lattey, Dr Jean Macintyre, Tim Pelquest-Hunt); Pfeiffer Wines (Jen Pfeiffer); SARDI (Dr Marcos Bonada, Roger Maywald, Dr Paul Petrie (from 3 December 2018)); Tarac Technologies (Brenton Mengersen); Treasury Wine Estates (Iain Jones, Josh Miles, Dr Anthony Robinson, Ian Shepherd, Dr Alison Soden, Dr Vanessa Stockdale); Università Politecnica delle Marche, Italy (Dr Laura Canonico, Dr Maurizio Ciani); University of Adelaide (Dr Dimitra Capone, Assoc. Prof. Cassandra Collins, Dr Lukas Danner, Assoc. Prof. David Jeffery, Ross Sanders, Assoc. Prof. Kerry Wilkinson); University of Bordeaux Institut des Sciences de la Vigne et du Vin, France (Prof. Philippe Darriet, Dr Panagiotis Stamatopoulos); University of California, Davis, USA (Prof. Andrew Waterhouse, Dr Aude Watrelot); University of South Australia (Dr Armando Corsi, Dr Miguel de Barros Lopes, Prof. Peter Majewski, Prof. Krasimir Vasilev); University of Talca, Chile (Assoc. Prof. Felipe Laurie); University of Tasmania, Tasmania Institute of Agriculture (Gail Gnoinski, Dr Fiona Kerslake, Dr Rocco Longo, Dr Angela Merry, Hanna Westmore); Vasse Felix (Michael Langridge); Vinpac International (Greg Edwards); Western Sydney University (Dr Gabriel Perrone); Wine Victoria (Rachael Sweeney); Wines by Geoff Hardy (Geoff Hardy, Shane Harris); Yalumba Family Winemakers (Heather Fraser, Teresa Heuzenroeder, Brooke Howell, Glynn Muster, Greg Nattrass, Louisa Rose).

Identification and control of compounds responsible for important sensory attributes

Background

Wine aroma and flavour are largely directed by numerous volatile aroma compounds. While many wine sensory attributes can be explained by knowledge of compounds previously studied, there remain several significant wine flavour characteristics where the causative compounds are not known. The ability to identify and measure compounds that give desirable flavour in wines is important to provide targets for grape and wine producers for improvements in vineyard practices and winery processes. This project is also studying innovative and less time-consuming sensory methods for wine evaluation, to better link wine flavour chemistry and sensory outcomes.

Methoxypyrazines in Shiraz and Pinot Noir: the role of whole bunch fermentations

The inclusion of stalks in a Shiraz fermentation was previously shown to cause an elevated concentration of methoxypyrazines, compounds that give a 'green' herbaceous character to wines. Methoxypyrazines were not previously thought to be important to Shiraz wines. A winemaking experiment was conducted with Adelaide Hills Shiraz and Pinot Noir grapes from the 2018 vintage. Wines were made with an increasing proportion of whole bunches, from 100% crushed and destemmed fruit (0% whole bunches) to 25%, 50%, 75% and 100% whole bunches. The results were very clear for both varieties, with a linear increase in 'capsicum' aroma and flavour with an increasing proportion of whole bunches, and an equally strong linear increase in isobutyl methoxypyrazine concentration (Figure 7). These results provide confirmation that inclusion of grape stalks in wine fermentations can change flavour towards 'green' attributes.

Effects of whole bunch fermentation on Pinot Noir and Shiraz phenolics

As part of the same study, researchers in the AWRI's texture team examined the effects of whole bunches on wine phenolics. A key question was whether tannins extracted from the stems would alter colour and astringency of the wines.

For Shiraz, it was found that a linear increase in tannin concentration occurred with the inclusion of whole bunches (600 to 1,400 mg/L) and this correlated strongly with the astringency of the wines. The type of tannin also changed with whole bunch inclusion, with tannins from stems found to be larger (polymer length) and more galloylated than those extracted from the skins and seeds of the grapes. Although the study could not distinguish different effects in terms of tannin concentration and structure on astringency, it will be of interest to further compare the mouth-feel properties of tannins derived from the different bunch components. Whole bunch inclusion in Shiraz also slightly increased wine colour (assessed both in the laboratory and visually by a sensory panel), but this did not change as whole bunch inclusion was raised over 25%.

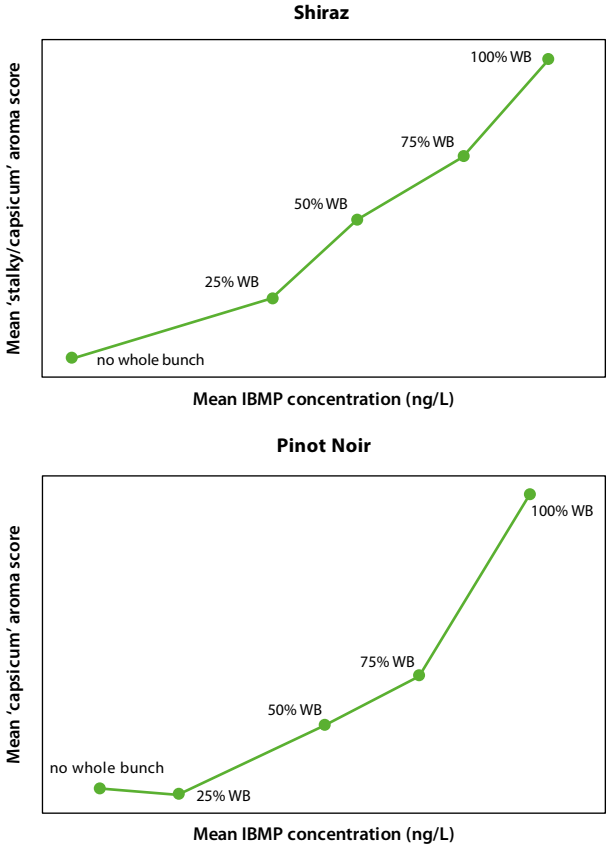


Figure 7. Relationship between 'stalky/capsicum' sensory score and isobutylmethoxypyrazine concentration for Shiraz and Pinot Noir wines fermented with different proportions of whole bunches

Figure 8. Visual comparison of wine hue in Pinot Noir wines produced with standard maceration (left) and with whole bunch inclusion (right)

In the Pinot Noir trial, very different results were seen. Tannin concentration was low (200 mg/L) in the control wine and was decreased with 25% whole bunch inclusion. As whole bunch addition was raised between 50% and 100%, tannin concentration varied, but did not exceed that of the control wine (200 mg/L). Wine colour density measured in the laboratory was reduced by all whole bunch addition treatments for Pinot Noir, but interestingly it was found that for the 75% and 100% whole bunch treatments, red colour intensity determined by a sensory panel was remarkably increased (Figure 8).

The drop in visual brown colour intensity rated by the sensory panel was found to be linear as whole bunch inclusion rate increased for Pinot Noir (Figure 9). Looking more closely at the analytical results for wine colour, it was surprising that the hue (i.e. the ratio of red and brown coloured compounds) of the wines remained constant. This was because both red and brown compounds decreased with whole bunch inclusion. The results highlight that at low concentrations of coloured phenolics, such as in Pinot Noir wines, losses of brown material may result in enhancement of perceived red colour.

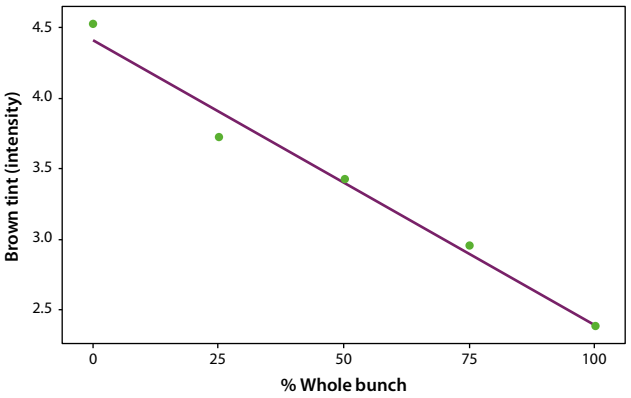


Figure 9. Linear decrease of visual brown colour intensity as assessed by a sensory panel when whole bunches were included during the fermentation of Pinot Noir wines

Further study of the relative ripeness of the stalk material would be of interest, as well the effect of whole berries, but this work provides winemakers with knowledge to consider the trade-off between improved colour and higher tannin against the possibility of enhanced 'green' flavour.

Understanding the role of varietal thiols in red varieties

Thiol compounds such as 3-mercaptohexanol (3-MH) and 3-mercaptophexyl acetate (3-MHA) are important flavour compounds in Sauvignon Blanc and other white varieties, where they contribute 'tropical fruit', 'passionfruit', 'grapefruit' and 'box hedge' characters. Much less is known about the sensory significance of thiol compounds in red wines. An aroma-only sensory evaluation was conducted to assess the sensory effects of the varietal thiols 3-MH and 3-MHA in red wine. The compounds were added at the highest concentrations found in a recent red wine compositional survey and in a Grenache winemaking project that assessed a wide range of yeasts. More 'fruity', 'green' and sometimes 'tropical' characters were described in the Cabernet Sauvignon, Pinot Noir and Grenache wines spiked with 3MH and 3MHA compared to the unspiked wines, but the effect was less obvious in the Shiraz wine. Further sensory studies are planned.

Foliar nutrient sprays and changes in varietal thiols

It is known that nitrogen fertilisation in the vineyard can influence thiol concentration in wines. The effect of foliar application of nitrogen and sulfur on Shiraz and Chardonnay grapevines in the Barossa Valley was assessed over two seasons, with two doses applied. The sprays resulted in increased concentration of amino acids and yeast assimilable nitrogen.

Sensory analysis of the 2018 Chardonnay and Shiraz wines showed only a small increase in 'grapefruit'/'tropical fruit' descriptors with the lower dose foliar spraying rate, but a surprisingly large sensory effect was found for the wines made with fruit from vines sprayed at the higher dose, for both varieties. The 3-MH concentration was strongly enhanced for both wine sets, with 3-MHA also increased in the Chardonnay foliar spray treatments. Importantly, low molecular weight sulfur compounds such as methanethiol (usually associated with off-flavours) showed no increase with the treatment. The results provide a straightforward means for producers to enhance the thiol-related 'fruity' characters in wines, including in warmer regions.

Riesling flavour: TDN and aged character

Riesling flavour characteristics, especially after some time in bottle, can be affected by the presence of TDN (1,1,6-trimethyl-1,2-dihydronaphthalene), sometimes described as 'kerosene-like'. If TDN is present early in a Riesling wine's life it can be considered detrimental. A collaboration with Hochschule Geisenheim University, Germany continued during the year, with the aim of assessing ways to reduce the propensity of Riesling wines to develop TDN and undesirable 'kerosene' characters. Aspects such as light quality and quantity at the bunch zone, temperature, row orientation and width have been investigated in vineyards in Germany and in the Eden and Barossa Valleys over several seasons. Accelerated ageing of wines from two vintages from these studies has been performed to predict TDN formation and sensory properties, as well as changes to other key Riesling compounds such as monoterpenes.

In vintage 2019 different shade cloth materials were used to manipulate bunch light interception and there was a clear decrease in total TDN (free TDN plus TDN from precursor forms) in juice at harvest as a result of the shade cloth treatments, with the decrease related to the amount of light transmitted to the bunches. Using HPLC-MS analysis it was demonstrated that the effects of light exposure on

carotenoid precursors to TDN and other flavour compounds were quite pronounced. From the 2018 and 2019 vintage experiments, black and green shade cloth were found to reduce overall carotenoid degradation, while red shade cloth strongly affected the carotenoid profile. Work is underway to identify the specific carotenoids that are the precursors to TDN. Results from this work were presented at the Oeno 2019/In Vino Analytica Scientia conference in Bordeaux in June 2019 where Yevgeniya Grebneva was awarded the inaugural Denis Dubordieu award for outstanding presentation by a young scientist.

'Stone fruit' flavour in white wine

Continuing earlier work on 'apricot' flavour, studies were conducted to investigate the influence of grapevine clone and harvest time on the concentration of monoterpenes in Viognier wine, with wines made from fruit from two regions. In addition, a new analytical method was developed combining the quantification of flavour-active lactones into one straightforward analytical procedure. Red wine samples from 10 varieties were analysed to assess the contribution of these compounds to red wine flavour.

To determine the flavour compounds responsible for 'peach' flavour, particularly in Chardonnay wines, a sensory-directed analytical study of wines with high and low 'peach' character was completed. A 'peach' reconstitution sensory study was conducted, to find which group of compounds was most important. The results clearly showed the influence of several fermentation-derived esters on 'peach' aroma. This study provides a major advance in knowledge on this sensory attribute, which should allow winemakers to adjust the level of this character through simple fermentation practices such as oxygen management, decreased juice clarification, yeast selection and lees contact.

'Raisin'/'jammy' flavour in ripe Shiraz

The volatile compounds that cause 'raisin' or 'cooked fruit' aroma, especially in late-picked Shiraz, are not well understood. A vintage experiment was completed to produce ripe and overripe grape samples and wines which will be studied through sensory and chemical analyses. GC-olfactometry analysis on grape berries from the previous vintage (with individuals acting as detectors to smell compounds as they are emitted from a gas chromatograph instrument) showed that several compounds are implicated and work is underway to quantify the relevant aroma compounds. Model chemical reaction experiments with sugars and amino acids provided evidence of the importance of pH and other conditions in the formation of several of these compounds, and this will be studied further.

Improved understanding of the impact of region and winemaking techniques on Pinot Noir wine

Commercial Pinot Noir wines were selected from five regions around Australia and five regions from around the world. Wine colour, tannin and volatile compounds were analysed and collaborators at the University of Tasmania will compare these results to sensory information and winemaking details to assess differences in chemical composition associated with wine regionality.

Sparkling wine autolysis trials

As part of a collaborative project with the University of Tasmania, Chardonnay and Pinot Noir sparkling wines made with different treatments to induce 'autolytic' or 'aged' character were analysed. Treatments included ultrasound, microwave, enzyme addition, storage at 15°C or 25°C and spiking with aged wine or lees. Comprehensive analysis of volatiles and non-volatiles was completed. As a final step, results will be compared to sensory data.

Assessment of rapid, alternative sensory methods

The Pivot© Profile rapid sensory evaluation method was applied using several groups of assessors with several variables investigated. A set of wines was assessed by a relatively large group of USA wine experts as part of Wine Australia's Australian wine showcase event held in Lake Tahoe, California, and broadly the same set of wines was tasted by a group of Masters of Wine at an event in Adelaide. The results have confirmed the usefulness of this method as a rapid technique for wine sensory assessment, and a computerised data acquisition system has been produced to allow simple data collection and analysis.

The collection of sensory information from consumers is fraught with challenges, with difficulties sometimes experienced in obtaining reliable data without biasing or misinterpreting results. A relatively new method which involves consumers tasting a set of samples and positioning them on a grid according to preference or choice has been developed by overseas researchers. This method was applied at the AWRI for the first time in red wine evaluation, with 56 consumers assessing a set of wines made from 'alternative' varieties, both fairly well-known varieties and more obscure ones. The wines were assessed under three conditions: knowing the label, vintage and variety, but with no tasting; blind tasting with no information; and informed tasting. A Shiraz wine was included as a benchmark. Varieties included Tempranillo, Lagrein, Saperavi, Sangiovese, Nero d'Avola, Graciano and Montepulciano.

The results showed that the method provides rich insight into consumer attitudes and preferences, including appropriate occasions and attitudes. The method was simple for consumers to apply, and appeared to be more discriminating than conventional hedonic scoring. The Lagrein wine included in the study showed potential as it was well liked both blind and with knowledge of variety, with the results indicating this variety, as well as Saperavi, was of interest to the consumers, and suited for consumption at restaurants and with friends. The Nero d'Avola was one of the least preferred wines under each testing condition. The results for informed and label-only conditions were quite similar for most wines, with the exception of Graciano (where taste helped consumers to accept the wine), and Sangiovese (where label knowledge increased acceptance of the wine). It should be noted that only one example was used of each variety, and these results should not be generalised.

Understanding and mitigating the development of off-flavours related to indole in sparkling wine

Background

Australian wine companies have increased production of tank-fermented white sparkling wine in recent years to meet market and consumer demand. A number of AWRI helpdesk investigations identified indole off-flavour (described as 'chemical', 'plastic', 'mothballs') in some tank-fermented white sparkling wines and found that white sparkling wines produced by this method are particularly susceptible to accumulation of indole during the secondary tank fermentation. This project is investigating sparkling wine production practices, processes and equipment to develop an understanding of the key drivers behind the formation of indole off-flavour in tank method sparkling wine and identify ways to prevent it.

Factors associated with occurrence of indole in sparkling wine

Samples of 140 tank-fermented sparkling wines were collected. Samples of yeast cultures, base wines and the associated finished sparkling wine were also collected. All samples were tasted, with 16 of the finished sparkling wines identified by a sensory panel as being affected by indole-like characters. These wines were confirmed to contain a concentration of indole near to or greater than its sensory threshold. Quantitative analysis of known precursor compounds and/or breakdown products was conducted with no clear correlations identified. Non-targeted metabolomic analysis also did not separate or identify differences between ferments that generated indole and those that did not. Metagenomic analysis of propagation cultures showed no evidence of a relationship between microbial community structure and indole concentration in finished wine. Results to date point towards indole production occurring via a yeast-mediated metabolic pathway. Next steps will involve studies to investigate in more detail the sensory significance of indole and other related compounds that may also be involved in the off-flavour.

Using glycosides and other flavour precursors for improved wine flavour

Background

Odourless grape-derived glycoside compounds in wines can be broken down during tasting, releasing a surge of long-lasting flavour. This effect occurs due to enzymes from salivary bacteria. Previous work showed that there is a wide range of responses among individuals, with some easily able to perceive strong flavour from all types of glycosides, some only able to perceive flavour from some precursor compounds, and others who report only a weak taste or do not respond at all.

Over the last year, work has been underway to try to understand the reasons for this variation. There has been particular interest in assessing whether it might be due to differences in salivary bacteria types among people, inhibition of the bacterial enzymes or differences in ability to perceive the flavour released.

Factors contributing to individual differences in sensory response to glycosides

Forty-one people were assessed for their ability to perceive flavour from two types of glycosides, tasted at a moderate concentration. The proportion of glycosides broken down by each person's saliva was also assessed chemically using GC-MS and LC-MS methods. While there was a large difference among individuals in the ability of their saliva to release volatiles from the glycoside precursors, surprisingly the percentage released did not correlate with the individual's flavour perception. AWRI bioscientists completed a detailed metagenomics study and found that there were two distinct groups of people with different bacterial communities. The group with low ability to release glycosides had a different bacterial community from the group who could release a high proportion of glycosides. However, the ability to perceive flavour from the precursors did not relate to the groups identified from the metagenomic study, nor the saliva hydrolysis data.

The last pieces of the puzzle – the sensitivity of each individual to the flavour of the glycosides and their sensitivity to the free volatile compound – were determined using a large series of sensory detection tests at low concentrations with 24 of the test subjects. The sensory detection values for each person were found to relate very well to the classification of people as glycoside 'tasters' or 'non-tasters'.

Thus it seems that although individuals can differ in the innate ability of their saliva to break down glycosides and release flavour, it is the sensitivity of the olfactory system that is the true predictor of whether someone can easily taste flavour from these compounds. Some individuals' saliva has a low ability to release the flavour from the precursors, but they can nevertheless taste the glycosides, as enough flavour can be released. The saliva hydrolysis was not the limiting factor for the people tested. These results show that most people can perceive flavour from glycosides if they have the olfactory ability to perceive the released flavour compound, providing evidence that in-mouth release of flavour during wine consumption from this source is a common experience, rather than being limited to only a fraction of people.

Understanding flavour precursors in winemaking

To better understand the types of flavour precursors present in grape skin, numerous marc samples from different varieties were extracted and analysed. Muscat varieties showed the highest concentration of bound monoterpenes, with Muscat Gordo the highest by two-fold. Viognier extract showed the highest release of 2-phenylethanol ('floral', 'rose') after acid hydrolysis, showing it may be useful for increasing specific attributes in wine.

Studies of glycoside stability over time were conducted, with different sugar structures under different conditions. This is relevant to consideration of the timing of possible glycoside additions in wine production at different pH values. No differences in degradation were seen under the different conditions studied. As such, optimisation of the glycoside profile (type of sugar) in the source material is not required, when considering producing marc extracts for addition to wine. With respect to volatile evolution, lower pH wines resulted in higher concentrations of rearranged monoterpenes, with the likelihood of a shorter shelf life of wines made at lower pH with enhanced glycosides. More extensive studies will be conducted.

Molecular drivers of wine texture and taste

Background

Wine textures play a key role in the quality and typicality of white and red wines. Achieving desirable texture can be challenging, with many components potentially contributing to the overall mouth-feel. Knowledge of the identity and origins of contributing compounds will enable winemakers to better manage the texture of wines during production and optimise positive characters while minimising negative ones.

Factors influencing taste and texture during winemaking

The evolution of polysaccharides during the entire process of white winemaking was determined for the first time. In Sauvignon Blanc and Chardonnay (Figure 10, Sauvignon Blanc shown), the concentration of medium molecular weight (MW) polysaccharides previously shown to contribute positively to white wine texture by reducing hotness and increasing perceived viscosity was reduced during settling off grape solids and significantly reduced from the middle stages of fermentation to pre-bottling. The concentration of high MW polysaccharides (consisting mainly of mannoproteins) that assist in protein and cold stability was stable during juice settling but increased throughout fermentation and through to the pre-bottling stage. The concentration of low MW polysaccharides thought to be extracted from skin fragments increased steadily throughout the winemaking process.

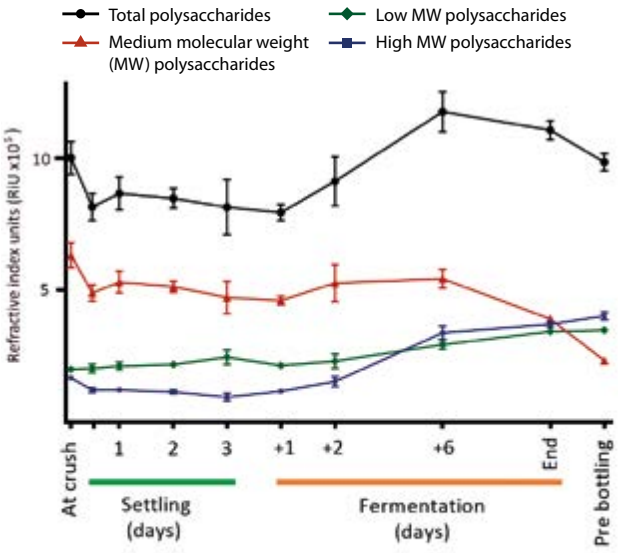


Figure 10. Evolution of polysaccharides during the making of a 2019 Adelaide Hills Sauvignon Blanc wine

Understanding the drivers of negative wine characters

Recent investigations indicated that tryptophol sulfonate contributes negatively to white wine by adding bitterness and hotness. Knowledge of its formation and interfering factors will therefore assist in developing strategies to reduce its impact. To facilitate this, a simpler, cheaper, faster and more sensitive method to measure tryptophol sulfonates and related compounds in red and white wines using HPLC with fluorescence detection was developed.

Factors influencing tryptophol sulfonation were explored using Gewürztraminer and Chardonnay wines. After fermentation using a newly developed high tryptophol-producing 'rose' yeast, the effects of wine pH and SO_2 were investigated by monitoring the samples over time. Sulfonated tryptophol formed more readily at high pH (3.6) compared to low pH (3.2) and more so in Gewürztraminer

(200% increase at high pH compared to the control) than in Chardonnay (30% increase). Importantly, sulfonation of tryptophol mostly occurred post-ferment following SO_2 addition.

A further investigation was conducted with large-scale ferments to assess the potential impact of sulfonation on sensory profiles. Riesling, Gewürztraminer and Chardonnay grapes from 2019 were fermented in single-batch, large-scale ferments using the high tryptophol-producing 'rose' yeast. After ferment, wines were split into triplicate 20 L batches and different concentrations of SO_2 and acid were added to give wines with high and low doses of SO_2 at high and low pH. Wines will be monitored to assess the formation of tryptophol sulfonate until sensory analysis at 12 months post-bottling.

Wine polysaccharides may influence the perception of bitter molecules in wine due to interactions that prevent the molecules from interacting with oral receptors. To assess this possibility, nanoparticle tracking analysis was used to assess the interaction between tryptophol sulfonate and characterised polysaccharides previously derived from white wine. The particle size distribution of medium and low molecular weight polysaccharides was generally shifted upward when tryptophol sulfonate was added, suggesting that the taste-active tryptophol sulfonate interacts with wine polysaccharides, potentially reducing its bitter impact. Further work to confirm the exact nature of this interaction will be conducted.

The protein casein used to remove phenolic-induced bitterness from white wine was trialled as a potential fining agent for tryptophol sulfonates. Using typical fining rates, casein was partially effective in removing low levels of tryptophol sulfonates, but it was ineffective at removing tryptophol sulfonates at levels typically found in Australian wines. Moreover, the discovery that tryptophol sulfonates mostly form late in the winemaking process practically rules out the use of traditional amelioration steps including protein fining.

Managing wine extraction, retention, clarity and stability for defined styles and efficient production

Background

This project investigates wine macromolecules such as tannins, polysaccharides and proteins to understand their impact on wine stability, clarity, filterability, sensory properties and style. A key focus area has been to develop tools to better achieve and measure wine protein stability. Tannins, anthocyanins, polysaccharides and their interactions are studied to inform the use of wine additives, or to improve colour and cold stability. The new knowledge and tools generated provide winemakers with options to address stability, clarity, and ultimately production efficiency during winemaking.

Bentonite alternatives for the heat stabilisation of white wines

This year, for the first time, the use of natural zeolite as an alternative to bentonite to remove the principal proteins responsible for white wine haze was evaluated. Zeolite has been widely used as a catalyst, separator, water softener and desiccant, but importantly from a wine production standpoint it meets the requirements for protein adsorption. Zeolite is also easy to use and cheap compared to many other types of commercially available adsorbents. Figure 11 demonstrates the likely mechanism of protein adsorption by zeolite.

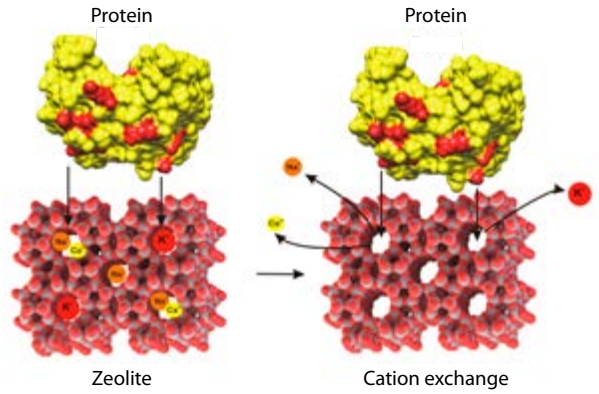


Figure 11. Schematic diagram of the protein adsorption mechanism by zeolite

Previous studies have shown that many bentonite alternatives require high doses to be effective. For zeolite, a lack of swelling behaviour can reduce lees production relative to a number of commercial bentonites (Figure 12). In terms of effectiveness, the results showed that treatment with zeolite in the size range of 20-50 microns with an exposure time of three hours was sufficient to achieve complete heat stability. Three white wines were tested, and the results are shown in Figure 13. The Semillon wine was fully stabilised by applying 4 g/L of zeolite, while the Sauvignon Blanc and Chardonnay wines required a 6 g/L dose. Furthermore, it was found that zeolite selectively removed potassium (more than 30%), presenting an opportunity to further study the application of zeolite for improved cold stability. The results of this study show that zeolite may offer a promising alternative to bentonite (Mierczynska-Vasilev et al. 2019).

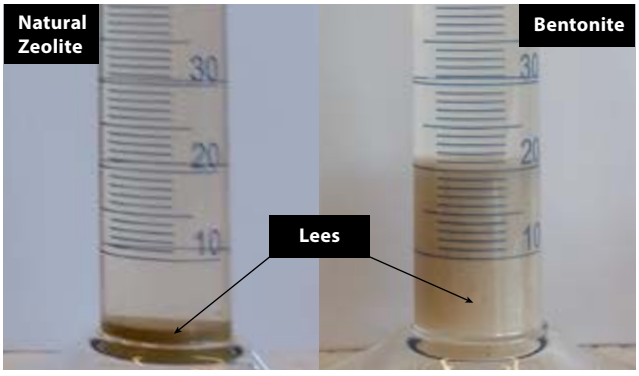


Figure 12. Lees volume in Semillon wine after treatment with zeolite and bentonite

Understanding the role of wine macromolecules in cold stability

Red wines are known to be more difficult to cold stabilise through induced crystallisation than white wines, and this has long been understood to be due to the presence of higher concentrations of rhamnogalacturonan II (RGII) and polyphenols such as tannins (Gerbaud et al. 1997). These macromolecules can cooperatively inhibit crystal growth through fouling of the crystal surface.

Interestingly, although yeast mannoprotein products are marketed as cold stabilisation additives for wine, early research (Gerbaud et al. 1997) actually showed that they were less effective than RGII as crystallisation inhibitors. Since RGII naturally occurs in wine and can be modified by winemaking techniques, this project has revisited this earlier work to better understand the relevance of RGII as a natural cold stabilising agent. A study was performed on two cold-unstable white wines which

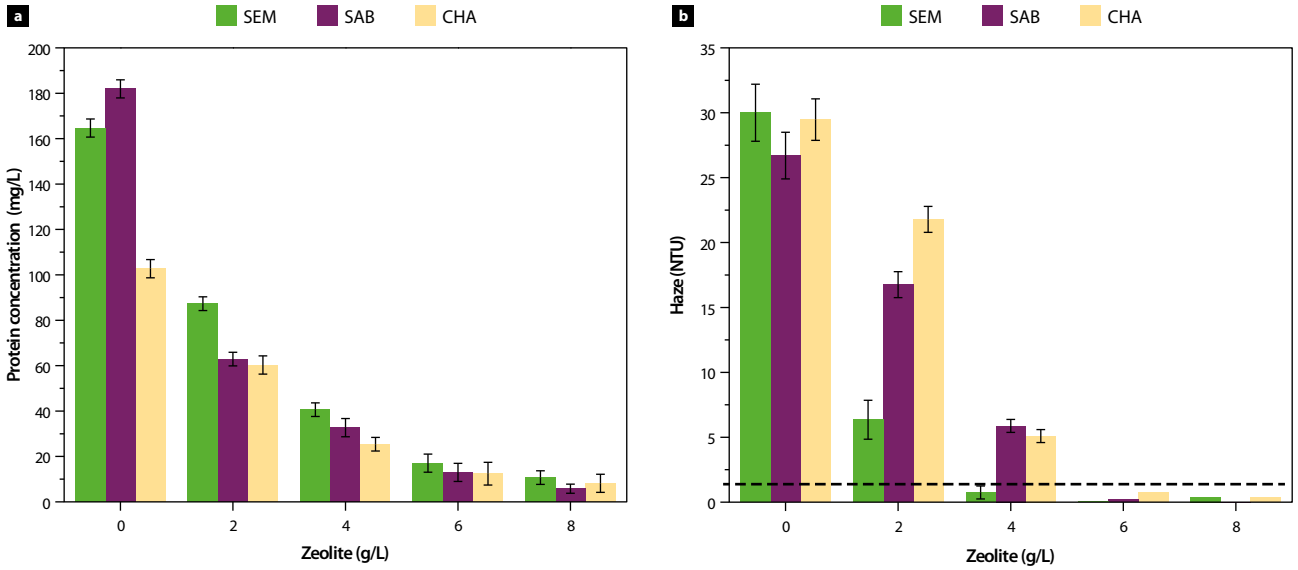


Figure 13. The effect of zeolite dosage on (a) protein concentration and (b) haze formation following a heat test in Semillon (SEM), Sauvignon Blanc (SAB) and Chardonnay (CHA) wines. Dotted line indicates haze <2 NTU after the heat test – an indication of heat stability.

had not received bentonite addition. It was found that the addition of RGII to white wine at wine-like concentrations improved cold stability from a level 3 fail in the three-day cold test (visible crystals to the naked eye) to a pass for one of the wines (Sauvignon Blanc) but was not as successful for the other wine studied (Semillon) which only improved to a level 2 fail (>10 small and/or larger crystals). Both wines were compositionally very similar in terms of polysaccharides, protein, organic acids and potassium. Future research will aim to understand the conditions under which RGII can successfully inhibit potassium bitartrate crystallisation.

A further study aimed to understand the role of tannin structure in red wine cold stability, taking note of the anecdotal evidence that some red wines are initially cold stable, but may lose this stability during processing, bottling and ageing. A key factor which changes during the life of a red wine is the incorporation of anthocyanins as part of the tannin structure to form polymeric pigments. As a result, tannins become less 'grape-like', more cross-linked and potentially less reactive. The three-day cold test was conducted on a cold-unstable white wine after the addition of 0.5 or 1 g/L of grape tannin or wine tannin (sourced from a young wine or an aged wine). It was found that grape tannin added at only 0.5 g/L could significantly reduce crystallisation during the cold test. Wine tannin could also markedly reduce crystallisation, but only at higher concentrations. The age of the wine tannin did not change the response (Figure 14). The results suggest that for wines with low tannin concentration, changes to tannin structure that occur during fermentation and ageing may change the cold stability of a wine. This opens a possible alternative role for commercial grape tannin additions during red winemaking, to improve cold stability.

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Mierczynska-Vasilev, A., Wahono, S., Smith, P., Bindon, K., Vasilev, K. 2019. Using zeolites to protein stabilize white wines. *ACS Sustain. Chem. Eng.* 7(14): 12240-12247.

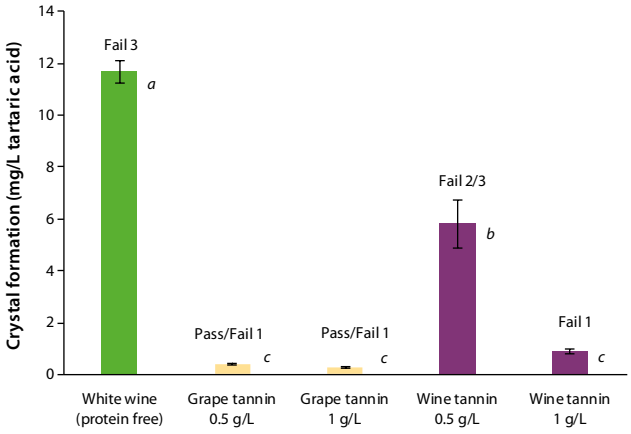

Figure 14. Potassium hydrogen tartrate crystals recovered from a protein-free white wine after a three-day cold test at -4°C either before (green) or after the addition of a grape skin tannin (yellow) or wine tannin (purple) at either 0.5 or 1 g/L. (Note: level 1 fail = borderline fail, <10 small crystals; level 2 fail = bad fail, >10 small or larger crystals; level 3 fail = crystals visible to the naked eye.) Different letter labels on the bars denote statistically significant differences.

Influencing wine style and efficiency through management of oxygen during wine production

Background

This project is using both model systems and pilot-scale fermentations to investigate the impacts of oxygen exposure at crushing or during fermentation on fermentation efficiency and wine style. It is also monitoring wines with known oxygen exposure as they age, to assess oxygen-related chemical changes that occur after fermentation. Different approaches to oxygen delivery are being explored in collaboration with industry partners.

How much aeration is too much? Testing the limits of white and red fermentations' capacity to tolerate aeration

Previous work has shown that introduction of air or oxygen during the active phase of fermentation can be beneficial. In white grape ferments aeration can be used to stimulate fermentation rate, especially in low turbidity musts, without significant impact on the sensory qualities of the finished wine. In red grape ferments, aeration has a minimal impact on fermentation kinetics; however, stylistic changes associated with tannin structure and abatement of 'reductive' characters, particularly as wines age, have been observed.

In the experimental work to date, characteristics associated with oxidation related to excessive aeration have not been observed, in either white or red fermentations. In 2019, pilot-scale (500 L) experiments were undertaken to investigate the aeration capacity limits of red and white fermentations. Sparging of ferments was undertaken at a rate that achieved 40%, 10% and 1% air saturation. These treatments were initiated four days post-inoculation when sugar was at 80% of the initial concentration. Aeration treatments were maintained for 48 hours at a constant input flow rate of air.

In white ferments the minimal aeration treatment was sufficient to stimulate fermentative activity, reducing overall fermentation time by four days. No further reduction in ferment duration was observed with increasing oxygen treatment. A lesser impact on fermentation kinetics was observed in red fermentations, with their duration reducing by two days with the highest oxygen treatment. Signs of oxidation did become evident, especially in the whites, with 10% and 40% air saturation treatments resulting in wine quality downgrades. Red wines were more robust toward oxygen treatments at all treatment levels. Chemical and sensory analysis will be used to quantify the impacts of the aeration treatments. These experiments highlight the practical differences between white and red winemaking for use of oxygen in the winery and demonstrate the limits of using aeration as a tool in winemaking.

Aeration of wild ferments

Aeration of inoculated ferments, as described above, is usually timed to maximally intersect with growth of *Saccharomyces cerevisiae* in order to either maximise the benefit to its growth for white ferments, or to provide opportunity to interact with the wine matrix in the case of red ferments. Non-inoculated fermentations introduce a different combination of possible interactions. Modulating the timing of aeration affords the opportunity to interact with different members of the microbial community that can be dominant during the early phases of a fermentation and potentially enhance the survival of selected members.

The question of how aeration could be used to modulate non-inoculated fermentation was approached using freshly prepared Chardonnay must without SO_2. Three different treatments were applied, all of the same intensity (2.5% air saturation) and duration (24 hours) but applied at 24, 48 or 72 hours post-must preparation. The effect of aeration on the duration of uninoculated fermentations was more pronounced than for inoculated ferments, being reduced by as much as seven days depending on when the aeration was applied. The effect of microbiological community structure is being assessed using a metagenomic approach. Whether aeration will prove to be as useful to the management of non-inoculated fermentations as it is proving to be for the management of inoculated ones will continue to be of interest within this project and will form part of ongoing work.

Oxygen transfer to ferments

Whether transfer of oxygen to fermenting must occurs in large red fermenters that use air mixing equipment (most commonly used in larger wineries for cap management) remains an unanswered question. The large bubble size produced by this sort of equipment should preclude any useful gaseous exchange. To understand whether this was the case, several dissolved oxygen (DO) data loggers were suspended in four 150-tonne fermenters equipped with Pulsair® mixing at 1, 3 and 5 metres from the bottom of the fermenter for the duration of the 2019 vintage (three to four fills). The DO peaked at 17% air saturation between 3 and 5 metres but this effect lasted only ten minutes per cap management cycle. Over the duration of fermentation this intake is potentially sufficient to induce oxygen-mediated effects in the finished wine. This work suggests that equipment already installed in many wineries could be used to implement an aeration strategy during fermentation.

Winemaking interventions to modulate glutathione status

Background

Glutathione (GSH) is a naturally occurring antioxidant present in grapes that plays an important role during winemaking. It can preserve wine colour and aroma by reacting sacrificially with quinones and acting as an antioxidant. It can also act as a precursor to a range of desirable and undesirable sulfur aroma compounds. The concentration of glutathione in wine can be enhanced by direct addition, or indirectly as a consequence of winemaking practices. The OIV has passed resolutions permitting the addition of GSH to juice and wine. With the possibility that glutathione could become a permitted additive to juice or wine in Australia, this project aims to extend current understanding about the effects of glutathione additions in white juices and wines.

What happens to glutathione when it is added to a ferment?

OIV resolution OIV-OENO 445-2015 provides limited guidance on the addition of glutathione to must, advising only that practitioners should ensure that the assimilable nitrogen level is sufficient to avoid the metabolism of glutathione by yeast. While the resolution limits the addition of glutathione to 20 mg/L, the conditions under which glutathione consumption by yeast is likely to occur are not specified and have not yet been determined.

Previous work in this project assessed the effects of nitrogen concentration on the consumption of glutathione during fermentation in defined medium and freshly prepared low yeast assimilable nitrogen (YAN) must. While glutathione consumption was observed at all nitrogen concentrations in these experiments, the additional glutathione did not alleviate growth limitations in low nitrogen conditions, indicating it was not utilised as nitrogen source in these experiments.

The consumption of nitrogen during fermentation was further investigated using yeast strains with different capacities for small molecule uptake. It is known that different yeast strains have different capacities to take up small molecules such as glutathione due to different complements of transporters. The consumption of glutathione by two near-identical yeasts was evaluated at three nitrogen concentrations (150, 320 and 430 mg/L YAN) and four glutathione concentrations (0, 20, 100 and 250 mg/L). Residual glutathione concentrations were found to vary with strain at low YAN and low glutathione concentrations, but as either the initial glutathione concentration or the initial YAN concentration increased, the strain-specific differences in glutathione concentration were no longer evident. For both strains the consumption of glutathione was highest at the lowest YAN and highest glutathione concentration.

Yeast strain and nitrogen concentration effects were also observed in the production of low molecular weight sulfur compounds. At low YAN, the addition of glutathione 24 hours post-inoculation was associated with increased post-fermentation hydrogen sulfide ('rotten egg' aroma) concentrations. This was not the case at moderate (320 mg/L) or high (430 mg/L) nitrogen concentrations. A similar but more pronounced effect was evident for methyl thioacetate concentrations ('sulfurous', 'cheesy' aroma), but in addition to nitrogen suppression of a glutathione-mediated response at higher nitrogen concentrations there were also yeast strain-related differences in production of this sulfur compound.

In summary, this work shows that at low glutathione doses, such as those recommended by the OIV, glutathione consumption by yeast can still occur at low must nitrogen concentrations. Some production of glutathione by yeast does also occur and contributes to the overall final glutathione concentration. Pre-ferment glutathione addition can contribute to low molecular weight volatile sulfur compound production (i.e. 'reductive' aroma compounds), but the degree to which this occurs can be dependent on yeast strain and nitrogen concentration.

Putting microbial diversity to work in shaping wine style

Background

While there are a large number of wine yeasts currently available for winemaking, extensive genetic analysis has shown the genetic diversity among these yeasts to be extremely shallow. This limited genetic depth provides substantial scope to expand the genetic diversity of wine yeasts through breeding and selection. This project builds on previous work in which *Saccharomyces cerevisiae* was mated with non-*cerevisiae* members of the *Saccharomyces* genus to produce genetically complex hybrids and work where non-GM methods of selection were employed to develop low hydrogen sulfide and low acetate producing yeasts. Together these breeding and selection strategies will deliver non-genetically modified germplasm that can be used by industry and will provide new microorganisms for winemakers seeking a point of differentiation in their wines.

Rebuilding the rose – bringing floral aromas to different yeast backgrounds

For some time amino acid analogues have been used as selective agents to drive alterations in amino acid metabolism, and hence aroma compound production, in wine yeast. The first generation of these yeasts produced very high concentrations of phenylethyl alcohol (PE), phenylethyl acetate (PEA), tryptophol and tyrosol. The overt 'rose' aroma associated with those very high concentrations of PE was perceived as being out of balance and the high concentrations of tryptophol and tyrosol drove bitterness, particularly in red wines.

In an attempt to address these issues, trials were undertaken with a second generation of PE-enhancing yeasts which exhibit a spectrum of PE and PEA production potential. Chardonnay wines made with these yeasts were assessed by a trained sensory panel. Despite this second generation of strains producing between two and fourteen times the concentration of PE and five to thirty-two times the concentration of PEA, only the wine with the highest concentration was perceived as been more 'floral'. Wines with concentrations of PE between two and eight times higher than the control wine were not perceived as having increased 'floral' aroma.

Another factor influencing the performance of these PE-enhancing yeasts is the parent strain from which they were originally derived. With poor pH and SO_2 tolerance, the original parent is not optimal for white wine production. A third generation of amino acid analogue resistant strains was therefore produced this year. These isolates have not only been screened for their PE and PEA production potential but also their capacity to produce tryptophol and tyrosol. Together with one of the moderate PE producers trialled in vintage 2018, two of the third-generation isolates were applied in pilot winemaking trials to assess their suitability for production of sparkling wine, for both primary and secondary fermentation. Final evaluations of these wines will be undertaken in the second half of calendar year 2019.

Digging into the details of wine yeast hybrids

A previous project generated a *Saccharomyces cerevisiae* x *Saccharomyces uvarum* hybrid that exhibited low acetate production in high sugar conditions. The concentration of acetate produced by this hybrid was not intermediate between the two parents, but significantly less than both, suggesting an unusual genetic interaction. To investigate this further, a large collection of progeny resulting from the sporulation of the hybrid was generated. This collection shows variance in the concentration of acetate produced, which can be used to map the determinants of the low acetate trait. This mapping is being undertaken using a method known as quantitative trait loci analysis. It is hoped that this work will allow a better understanding of how genomes as different from each other as *S. cerevisiae* and *S. uvarum* respond when they come together in the same individual.

In related work, the contribution of hybrid yeast to non-volatile wine composition is being explored in laboratory-scale red grape (Tempranillo) fermentation trials. Hybrid strains with different combinations of *S. cerevisiae* wine yeast and non-*cerevisiae* parents were included in the trial in order to evaluate the impact of differing *S. cerevisiae* genomic heritage on interspecific hybrid winemaking capabilities. Hybrid-dependent variation in total polysaccharides was observed, driven primarily by differences in the low molecular weight polysaccharide fraction. These are known to be released from pectins found in the grape cell wall. The majority of the variation in low molecular weight polysaccharides was related to the *S. cerevisiae* parent of the hybrid, with only minor contributions from the non-*cerevisiae* parents evident. This work is providing the foundations for a more nuanced approach to selecting parental strains for the generation of wine yeast hybrids.

A vintage trial comparing seven different interspecific hybrids, all products of rare mating with diverse non-*cerevisiae* species, was undertaken in 2018. This was the first 'head-to-head' comparison of such a diverse array of hybrids. The resultant wines underwent sensory assessment and chemical analyses for volatile flavour-active fermentation products, polysaccharides and haze-forming proteins. Sensorially, wines produced from the hybrid strains were rated higher in 'fruit' and 'banana' aroma and flavours (*S. cariocanus*, *S. kudriavzevii* and *S. mikatae*) as well as 'floral' aroma and acidity (*S. eubayanus* and *S. arboricola),* while the *S. uvarum* hybrid wines were rated highly for 'honey' aroma and yellow colour. These results aligned with the chemical analyses for compounds known to produce 'fruit' aroma (ethyl butanoate), 'banana' aroma (3-methyl butyl acetate) and 'floral' aroma (PEA). Differences were also observed in wine polysaccharide composition (*S. uvarum*) and haze-forming protein concentration (*S. kudriavzevii*, *S. uvarum*, *S. eubayanus* and *S. arboricola*) but the winemaking significance of these findings is yet to be determined.

The relationship between grape juice composition and the progress of alcoholic and malolactic fermentation

Background

This project brings together two previously separate research areas, yeast and bacterial fermentation, in order to realise an integrated approach to the study of fermentation performance. Poor fermentation progress can occur even in juices and wines that satisfy the usual criteria for appropriate fermentation progress (e.g. YAN, Baumé, SO_2). The starting point for any ferment, the juice, is a rich ecosystem and the uncontrolled growth of non-target microorganisms can be inhibitory to alcoholic or malolactic fermentation, either through competition for nutrients or through the production of secondary metabolites. In addition, simultaneous alcoholic and malolactic fermentation are increasingly being used to more efficiently manage winery scheduling. The interactions of different microorganisms with the grape juice environment, both individually and as a community, and how those interactions shape fermentation performance, are key areas of focus for this work.

Managing interactions between yeast and bacteria

There is no better example of an intimate relationship between yeast and bacteria than when co-inoculation of *Saccharomyces cerevisiae* and *Oenococcus oeni* is used to stimulate the simultaneous conduct of alcoholic and malolactic fermentation (MLF). This increasingly common practice can be a boon under ideal conditions as alcoholic and malolactic fermentation can be completed simultaneously. However, the benefits in more trying conditions are not always so obvious. At times, the duration of co-inoculated and sequentially inoculated MLF can be equivalently protracted. The success or failure of co-inoculated MLF rests with the close relationship between *S. cerevisiae* and *O. oeni* and this relationship has remained a focus for this project.

The kinetics of SO_2 production by wine yeast

Previous work at the AWRI and elsewhere demonstrated the large range of SO_2 production potential for different strains of wine yeast. The SO_2 produced remains in the wine bound to other metabolites, predominantly acetaldehyde, and is one of the inhibitory factors to consider when conducting sequential MLF. During the conduct of co-inoculated MLF, however, the kinetics of SO_2 production may be relevant to the optimal timing for *Oenococcus oeni* inoculation. For this reason, SO_2 accumulation was monitored during alcoholic fermentations conducted by a selection of yeasts with different SO_2 production potentials. This work demonstrated that not all yeasts begin SO_2 accumulation at the same time or at the same rate and defined a window within 24 hours of yeast inoculation that would give *O. oeni* the greatest chance of establishing a sustainable population during co-inoculation.

Picking the right time for co-inoculation of *Oenococcus oeni*

In practice, the point of alcoholic fermentation when *Oenococcus oeni* is inoculated varies considerably from winery to winery. Typical recommendations suggest that inoculation of *O. oeni* should occur within 48 hours of yeast inoculation. Experimental work was conducted that aimed to provide further guidance about optimal *O. oeni* inoculation timing, considering the variable kinetics of SO_2 production by yeast. An investigation of co-inoculated Chardonnay juice showed a decline in the viability of bacteria at very early inoculation times (two hours post-yeast inoculation) which was ameliorated at 24 hours and exacerbated at 48 hours post-yeast inoculation. These observations align with the kinetics of SO_2 production by yeast discussed above. Bacterial survival was also highly dependent on yeast strain, with one high-SO_2-producing yeast yielding minimal loss in bacterial viability and MLF completion, while another caused complete decline of the bacterial population and no MLF. This demonstrates that bacterial tolerance to total SO_2 is not only dependent on the absolute SO_2 concentration and the timing of its production, but that there are other factors contributing to bacterial survival.

Another potential contributing factor to successful MLF is the SO_2 tolerance, or lack thereof, of *O. oeni* itself. Using a co-inoculation model system in Chardonnay juice, the strain-specific tolerance of 20 different *O. oeni* strains to SO_2 was assessed. Surprisingly, this assessment revealed that most strains of *O. oeni* did not exhibit sensitivity to high concentrations (≤ 60 mg/L) of acetaldehyde-bound SO_2. Further exploration of the mechanisms of *O. oeni* tolerance to acetaldehyde-bound SO_2

in co-inoculation may help address delays in MLF induction that can be encountered in white wines with potentially inhibitory SO_2 concentrations.

Interspecies microbial interactions – the strange world of *Aureobasidium pullulans*

Grape juice is a rich environment complete with its own ecology. One of the most abundant organisms present during the early stages of fermentation is a yeast-like fungus belonging to the *Aureobasidium* genus. While this organism is better known in relation to biotechnological and environmental applications, relatively little is known about its contribution to the progress and outcomes of fermentation. Recent work has sought to better characterise the physiology of strains of *Aureobasidium pullulans* isolated from spontaneous fermentations. Several compounds of oenological relevance were observed that are novel in the context of wine research. Assessment of the nutrient requirements of *A. pullulans* suggests that competition with yeast and bacteria is possible under specific conditions. These preliminary investigations will serve as a foundation for future work characterising the impact of this organism on wine production.

Management and optimisation of the AWRI Wine Microorganism Culture Collection

Background

The AWRI Wine Microorganism Culture Collection (AWMCC) originates from early microbiological investigations in Australian wines by John Fornachon in the 1940s and the earliest days of the AWRI. Since that time ongoing additions to the AWMCC from wineries and researchers across Australia have developed a repository that houses the Australian wine industry's microbial germplasm heritage. An electronic database is used to record information about each strain and to manage their movement (deposition and supply) and intellectual property. The AWMCC holds reference strains, research strains and a large number of Australian indigenous yeast and bacterial isolates. Many of these have yet to be identified and characterised for what they can bring to winemaking.

Identification, storage and distribution of microbial strains

In 2018/2019, a total of 2,690 yeast and bacterial strains were submitted to the AWMCC by researchers and wineries, including almost 2,300 from the bioprospecting project. This brings the total in the collection to approximately 18,900. During the year, the AWMCC distributed 637 microbial strains from cryogenic stocks. A new robotic incubator was installed to complement the high throughput liquid handling robot to be used for future high throughput screening of the culture collection. Laboratory microorganism handling procedures were also reorganised to more efficiently comply with legislative requirements.

Objective measures of quality and provenance in Australian vineyards

Background

This project forms part of a new multi-agency collaboration to research Shiraz terroir across a range of scales, primarily in the Barossa Valley. At the sub-regional scale, 23 sites were monitored with fruit undergoing sampling for ripeness, yield assessment, chemical analysis and small-lot winemaking. These sub-regions were identified by the Barossa Grounds Project, and are classified as Northern Grounds, Central Grounds, Southern Grounds, Western Ridge, Eastern Ridge and the Eden Valley (Figure 15). The AWRI's involvement in the project has been to perform multiple analyses of volatile and non-volatile compounds in the small-lot wines. In subsequent seasons, vineyard management interventions will be imposed on selected sites to determine the potential to optimise a site's terroir. These management practices will aim to influence vine growth and development, and to establish a cause and effect for environmental impacts on fruit and wine style.

Understanding the chemical diversity of Shiraz wines from Barossa sub-regions

For the first year of the study (2018), three or four Shiraz vineyards were selected from each of the six sub-regions, and three zones were chosen within each vineyard. From the wines made from each site, multivariate models were built using chemical data to distinguish the characteristics of each sub-region. It was found that the models were not able to successfully differentiate among the Barossa sub-regions apart from the Eden Valley. The Eden Valley has a greater elevation, and is notably cooler and wetter than the rest of the Barossa Valley, with 1,390 heat degree days (vs 1,710) and 280 mm of rain (vs 160 mm) during the growing season. The Eden Valley wines were defined by high concentrations of minor grape anthocyanins (non-malvidin) as well as higher levels of flavonols. They also had higher levels of hexyl acetate, and markedly lower concentrations of β-damascenone than wines from the remaining sub-regions of the Barossa Valley. Since the important phenolic and volatile compounds identified are influenced by environmental conditions such as sun exposure, temperature and potentially elevation, additional data will be required to reveal if there are inter-seasonal trends.

Digital solutions for grape quality measurement and management

Background

The primary objective of this project was to develop digital methods for rapid assessment of grape quality on delivery to the winery. The key parameters were the identification of *Botrytis*-infected grapes and the amount of matter other than grapes (MOG) in mechanically harvested loads. A secondary objective was to determine whether these methods could also be applied in vineyards for non-destructive *Botrytis* assessment of grapes on the vine.

Laboratory-based hyperspectral imaging

Images were collected with a laboratory-based hyperspectral linescan camera (Specim FX10) that collected images with spectral information over the 400-1000 nm wavelength range embedded in each pixel. This spectral information was used to classify each pixel in terms of its material class, and this classification was applied as a false colour image over the spatial information. The image analysis software packages used were Scyven and ENVI.

Hyperspectral imaging could discriminate clean and infected red and white grapes, both laboratory infections and field samples. The calibrations were not dependent on growing region, grape variety or *Botrytis* strain. The technique could also discriminate *Botrytis* infection from sour rot (mixed fungal and bacterial infection of grapes). Washing sporulating berries with grape juice and smashing berries to simulate mechanical harvesting also did not prevent identification of *Botrytis*. Hyperspectral imaging could also identify sunburn in white grapes and shrivel in red and white grapes and could discriminate other grapevine components that often form MOG in mechanically harvested grape loads: canes, wood, petioles, leaves and insects.

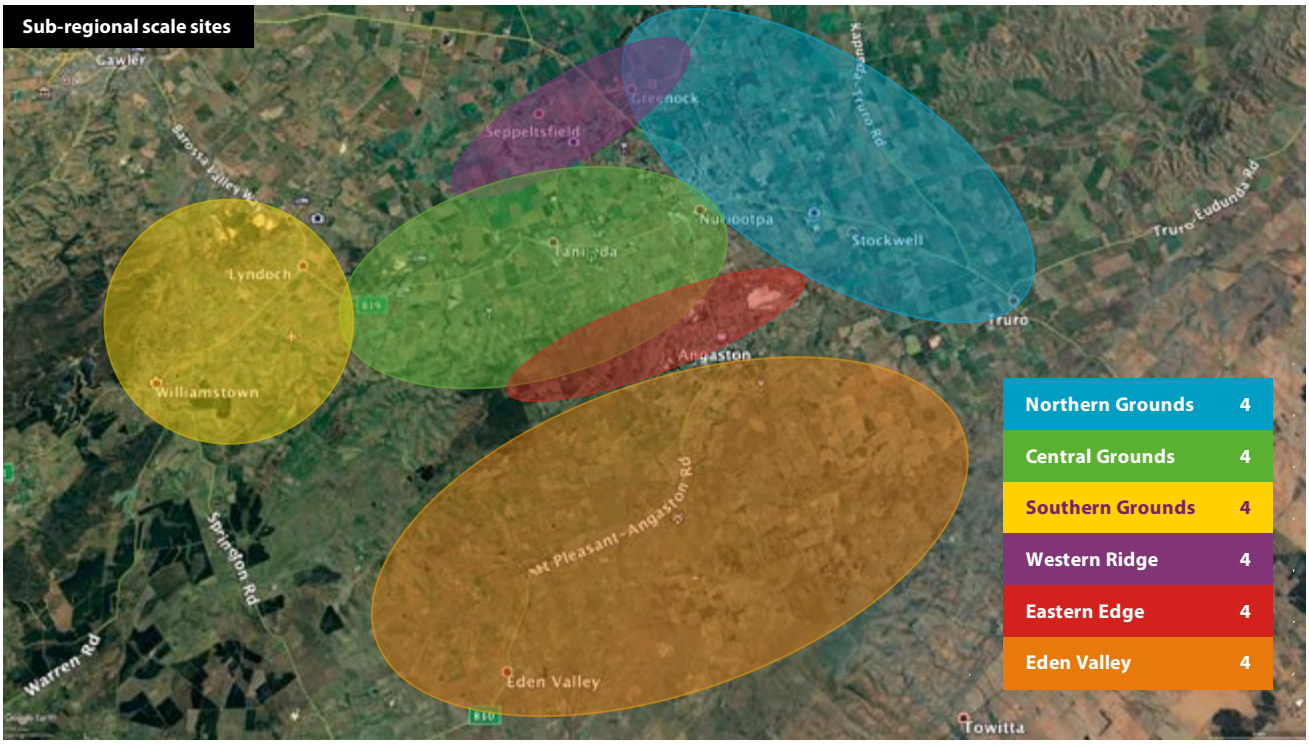

Figure 15. Sub-regional sites identified in the Barossa Valley to be used in the multi-agency Shiraz terroir project

Field-based multispectral imaging

Using information from the hyperspectral data, key wavelengths that discriminated different materials were used to select filters for a multispectral camera (Ocean Optics SpectroCam). This camera operates in snapshot mode like a conventional still camera, and does not require the sample to be moved under the camera, as with the FX10 linescan camera. Laboratory tests were performed to compare LED and halogen lighting. Images collected under LED lighting indicated insufficient output in NIR wavelengths (790, 860, 918, 972 nm) and only the first four filters (444, 531, 680, 717 nm) could be used for multispectral imaging. Halogen lighting was suitable over the whole wavelength range.

The multispectral camera was tested at a grape weighbridge testing station. Mechanically harvested grapes were imaged as a mass or spread out on a standard backing board. Most of the intake was at night and samples were imaged with either halogen or LED lighting, but other lighting conditions were also tested: full sunlight with halogen fill-in and the shaded testing tray area with halogen plus some ambient daylight. The most reliable identification of *Botrytis*-infected grapes and MOG occurred when samples were imaged on a standard background under halogen lighting.

The multispectral camera was also tested in the vineyard to image grapes directly on the vine. Multispectral imaging could discriminate infected grapes, clean grapes and grapevine tissue, but the system was not practical as the camera filter wheel stepper motor need a stable voltage to synchronise well, requiring use of a generator. Nevertheless, this work illustrated the potential of imaging *Botrytis* on the vine.

An important area of future work would be to create a robust imaging system where software controls the camera and seamlessly runs the image analysis in the background to report a result, with minimal user input. A vineyard imaging system requires development of portable devices with appropriate wavelength ranges and onboard image analysis capability. The ability to accurately monitor grape quality will be of economic importance to the wine industry and in the case of *Botrytis* infection will assist in setting suitable standards for infection level. A simple, robust system is required to encourage adoption.

Understanding *Brettanomyces* and its adaptation to control measures

Background

Brettanomyces yeast can cause wine spoilage by producing 4-ethylphenol and 4-ethylguaiacol, which are responsible for 'phenolic', 'leather', 'sweaty' and 'medicinal' aromas (collectively known as 'Brett' character). Although wine spoilage from this yeast was a major issue in Australian red wines produced during the late 1990s and early 2000s, the risk of 'Brett' spoilage is now commonly managed via a multi-faceted strategy disseminated by the AWRI, that enables winemakers to significantly decrease levels of 'Brett' spoilage compounds in finished wines. Yet, *Brettanomyces* has not been eliminated from Australian wineries, and loss of wine value still occurs. To ensure Australian winemakers' continued ability to manage *Brettanomyces* in a cost-effective manner, the control strategy must be future-proofed against potential market pressures to minimise levels of SO_2 in wine, and augmented with rapid detection methods.

Development of sulfur dioxide tolerance

A key question for the Australian wine industry is whether *Brettanomyces* may be developing tolerance to SO_2, as this would severely constrain current control strategies. Previous industry-based population surveys in the early 2000s showed that the strains of *Brettanomyces* with the highest levels of SO_2 resistance were most frequently isolated from Australian wineries (Curtin et al. 2007, Curtin et al. 2012). While this original study alerted Australian winemakers to the importance of SO_2 management for *Brettanomyces* spoilage control, current trends towards higher pH wines and the minimisation of SO_2 may provide conditions for *Brettanomyces* to develop further tolerance.

Initial studies conducted using historical industry isolates sourced from the AWRI Wine Microorganism Culture Collection (including those isolated during the 2007 study by Curtin et al.) and industry isolates sourced from two industry partners in 2016 and 2017 pointed to a shift towards increased SO_2 tolerance. Further sampling over 2018 (now from more than ten wineries) indicated a definite shift in SO_2 tolerance, with the 2016 to 2018 average tolerance approximately equal to the highest tolerances observed in isolates from 2000-2004 (Figure 16). Genetic testing will now be used to determine if these more tolerant isolates represent existing known genotypes that are evolving increased tolerance or new genotype(s) not observed previously.

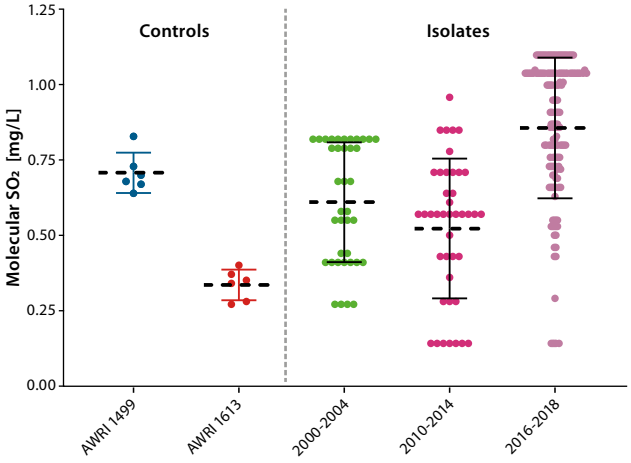

Figure 16. SO_2 tolerance of industry isolates of *Brettanomyces bruxellensis* over time. Industry isolates were sourced from wineries and/or the AWRI culture collection for three periods. Maximum SO_2 tolerance was calculated for each isolate. Maximum SO_2 tolerances for AWRI1613 and AWRI1499 (isolated during the 2000-2004 period) are shown as controls.

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Curtin, C., Kennedy, E., Henschke, P.A. 2012. Genotype-dependent sulphite tolerance of Australian *Dekkera* (Brettanomyces) *bruxellensis* wine isolates. *Lett. Appl. Microbiol.* 55(1): 56-61.

Formation and fate of sulfur compounds associated with negative attributes in wine

Background

Volatile sulfur compounds (VSCs) can contribute both positive and negative attributes to wines, and it is therefore desirable to be able to control their concentrations in a winery environment. The occurrence of VSCs can be influenced by factors including yeast selection and fermentation conditions; the nature and quantity of precursor compounds; the availability or absence of oxygen at different points of the winemaking process; and the availability and speciation of transition metal ions such as copper. By exploring the chemistry of VSC formation and the important role played by metals, these common winemaking observations can be better understood, potentially leading to recommendations for ways to reduce the risk of undesirable 'reduced' aromas and maximise positive aromas.

Evaluating 'reductive' aroma remediation strategies

Winemakers use various remediation strategies to manage 'reductive' aroma formation. Post-ferment addition of copper(II) sulfate has traditionally been used and it is an effective remediation technique in the short term (i.e. weeks to months), but recent research has shown that residual copper in wine can lead to increased formation of hydrogen sulfide (H_2S) and methanethiol (MeSH) post-bottling (i.e. on a time-frame of months to years). The presence of excess residual copper in wine post-treatment may increase the risk of liberating VSCs. Other remediation techniques, such as DAP (diammonium phosphate) additions, oxidative handling and racking, and fresh lees addition are also commonly employed to treat unwanted VSCs.

A study was conducted to assess the relative effectiveness of five commonly used 'reductive' aroma remediation strategies. Five sets of triplicate wines and a set of control wines (in triplicate) were prepared. On the onset of 'reductive' aromas, each wine was treated with a unique remediation strategy, namely (1) copper fining, (2) macro-oxygenation, (3) a combination of macro-oxygenation and copper fining, (4) DAP addition and (5) the addition of fresh lees.

The effectiveness of the different treatments was evaluated over 12 months via chemical and sensory analysis. All the remediation techniques had varying levels of effectiveness in removing 'reductive' aromas. Overall, the combination of macro-oxygenation and copper fining appeared to be the most effective in giving lowest 'reduction'-related attributes while enhancing 'fruity' attributes, while copper fining alone, lees, and (to a lesser extent) DAP addition, were shown to diminish 'fruity' attributes and confer 'reductive' characters (Figure 17).

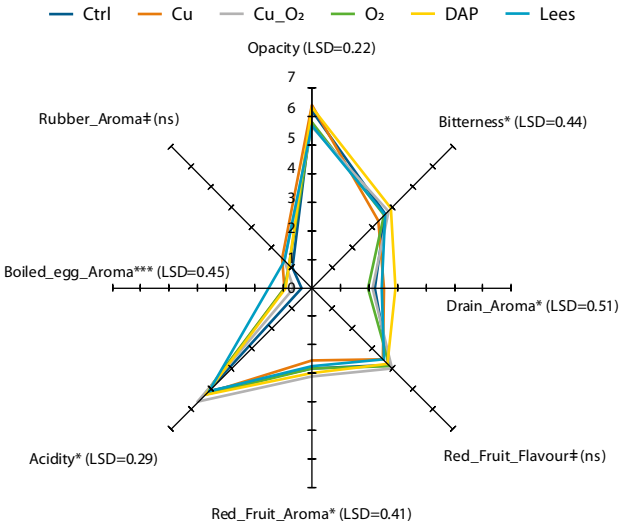

Figure 17. Mean sensory attribute intensity scores for significant attributes (*P < 0.05; **P < 0.01; ***P<0.001) and attributes approaching significance (‡ P < 0.16) for the 'reductive' aroma remediation treatments. Least significant difference (LSD) (P=0.05) values included for the significant attributes (P < 0.05).

Factors affecting the filtration of sulfide-bound copper in white wine

To understand the influence of the wine matrix on the filterability of copper bound to sulfide species, sulfide-bound copper was formed *in situ* with the addition of copper(II) sulfate and sodium sulfide to model and white wine in a collaborative study with Charles Sturt University. Five different membranes were examined (polyethersulfone, nylon, regenerated cellulose, teflon and glass fibre membrane) and the main components that influence the filterability were evaluated. In addition,

nanoparticle tracking analysis was used to differentiate between two possible action mechanisms of the filtration membrane on sulfide-bound copper filtration (particle size discrimination or adsorption).

As shown in Figure 18, the sulfide-bound copper particles in model wine were mostly below 200 nm in diameter, with an average particle size of 102 nm, whereas the particles in white wine were just below or within the 200-300 nm range, with an average particle size of 211 nm. Those results suggest that the removal of sulfide-bound copper from the model wine by the 0.2 µm regenerated cellulose (RC) filter is not due to a size-related mechanism but rather adsorption on the RC filter.

The concentration and size of copper sulfide-related particles in a Sauvignon Blanc wine was monitored over time after addition of copper(II) sulfate and sodium sulfide (Figure 19), and an increase of particle size was observed. At time zero, the mean size of sulfide-bound copper particles formed in Sauvignon Blanc was 175 nm and after 28 hours it increased to 240 nm.

To summarise, it was found that the removal of sulfide-bound copper by membrane filtration is hampered by white wine proteins and polysaccharides. This observation has been attributed to the adsorption of sulfide-bound copper species onto membrane filters, a process that is affected by the wine macromolecules and the filtration medium. The most apparent interferences from macromolecules were observed for regenerated cellulose, teflon and glass fibre membranes, whereas nylon and polyethersulfone membranes were capable of removing up to 40-90% of sulfide-bound copper from white wine. This finding sheds some light on what is happening in wine when winemakers treat 'reductive' wines with copper sulfate and then aim to use filtration to remove the copper sulfide particles. The work has recently been published in the *Australian Journal of Grape and Wine Research* (Kontoudakis et al. 2019).

Improved understanding of the role of microbiological factors in VSC formation

The sulfur-containing amino acid methionine has been identified as a precursor of the undesirable VSCs methanethiol (MeSH) and methylthioacetate (MeSAc) in laboratory-scale fermentations. High concentrations of methionine in a synthetic grape juice resulted in an increased formation of both MeSH and MeSAc during fermentation. In addition, the formation of MeSAc depended on the genetic make-up of the yeast used, and this may be linked to the presence of different allelic variants of ATF1, an alcohol acetyltransferase responsible for acetate ester production during fermentation.

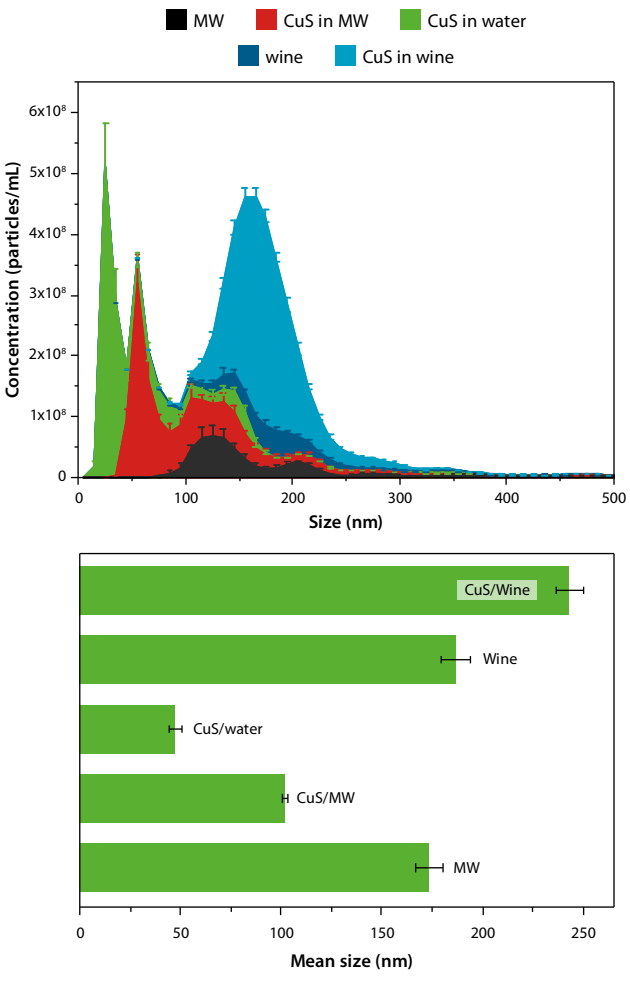

Figure 18. Particle size distribution profiles (top) and mean particle sizes (bottom) for model wine (MW), Viognier wine and for sulfide-bound copper in water, model wine and Viognier wine, following addition of copper(II) sulfate and sodium sulfide

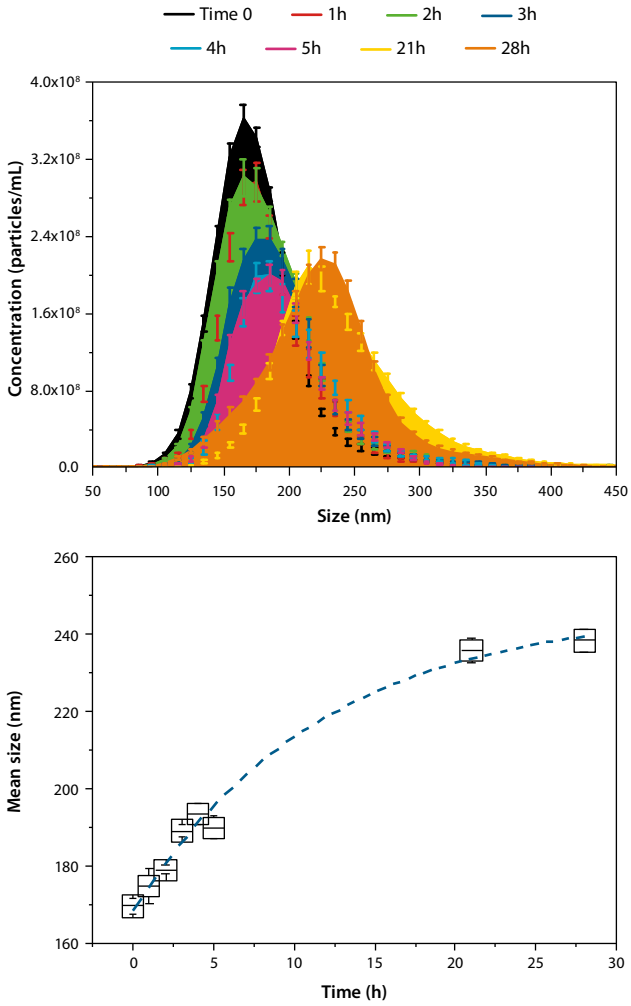

Figure 19. Particle size distribution profiles (top) and mean particle sizes (bottom) for Sauvignon Blanc wine over 28 hours after addition of copper(II) sulfate and sodium sulfide

Agnieszka Mierczynska-Vasilev

Commercial yeast manufacturers offer a wide range of yeast strains, but little information is known about their winemaking characteristics, particularly for red ferments. From a 2017 vintage trial of Grenache (50 kg) with six different wine yeast strains, it was confirmed that yeast strain selection is an easy and effective way to drive wine style in Grenache. For example, strain AWRI 2914, commonly used for the production of 'tropical' Sauvignon Blanc wines, produced twice as much of the 'fruity' thiols 3-MH and 3-MHA as the average of the other strains used (Figure 20). Wines made with AWRI 2914 were also rated highly in 'red fruit' and 'overall fruit' aromas, which indicate a possible contribution of 3-MH and 3-MHA in enhancing 'red fruit' aromas in Grenache. This work was published in *AWRI Technical Review* 236 (Cordente et al. 2018).

A peer-reviewed manuscript describing the role of the yeast enzyme IRC7 in the release of 'tropical' thiols from odourless precursors was published in *Applied Environmental Microbiology* (Cordente et al. 2019). This work has allowed the identification of IRC7 as a molecular marker that could be used to predict a yeast strain's potential to release 'tropical' thiols. This work was also presented in April 2019 at the Yeast and Fermented Beverage Flavor Symposium in California.

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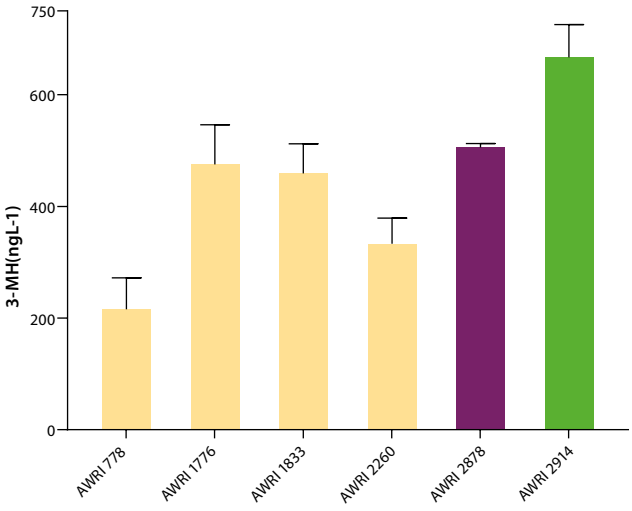

Figure 20. Production of the 'fruity' thiol 3-mercaptohexanol (3-MH) by six different yeast strains assessed in Grenache wines. Strains in yellow are classified as low thiol releasers, while strains in purple and green are classified as moderate and high thiol releasers, respectively. The aroma threshold of 3-MH is 60 ng/L.

Understanding and mitigating the development of 'reductive' characters in canned wine

Background

Recent industry trends indicate that wines packaged in cans are particularly susceptible to the formation of 'reductive' characters post-packaging. This has the potential to significantly damage consumer expectations for this packaging format and the brand integrity of

Australian wine packaged in this manner. A detailed understanding of the chemical pathways involved in the development of these 'reductive' compounds and the role of the packaging material in their formation is required. This knowledge will help identify potential remediation strategies to mitigate the risk of formation of 'reductive' characters, either prior to, or following, packaging in cans.

Benchmarking of canned commercial wines

Samples of 16 commercial canned products were monitored over a five-month period for concentrations of aluminium, SO_2 and volatile sulfur compounds (VSCs). Data were also collected on ullage (headspace) volumes and some of the products were subjected to oxygen transmission rate measurements, as well as imaging and elemental analysis, using scanning electron microscopy (SEM).

Results showed that most commercial canned wines experience a significant increase in aluminium concentration post-packaging (Figure 21) and many show elevated levels of VSCs (especially H_2S) during storage (Figure 22). Sensory evaluation showed that several products exhibited 'reductive' attributes and were rated as faulty by the AWRI technical quality panel.

Scanning electron microscopy images and subsequent x-ray analysis highlighted that there was direct contact between the aluminium body of cans and the wine inside, with evidence of pitting on the surface of the can interior.

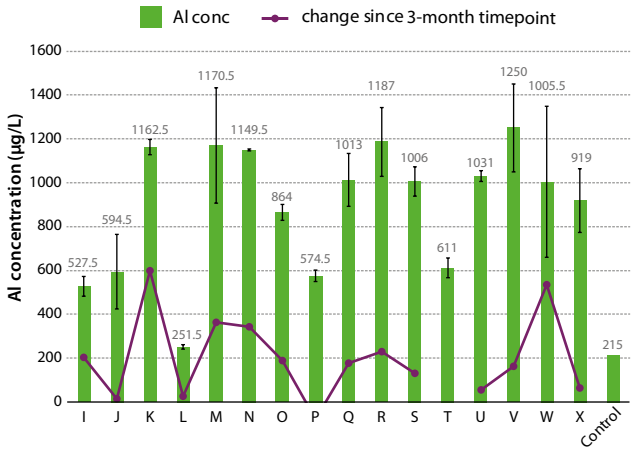

Figure 21. Aluminium concentration in 16 different canned wine products after five months in can; purple line shows the increase in the last two months

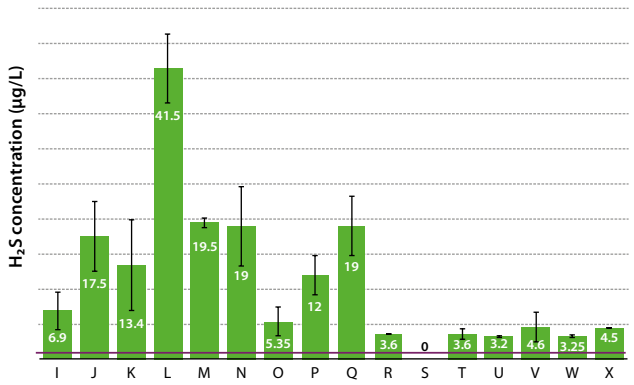

Figure 22. H_2S concentration in 16 different canned wine products after five months in can. Purple line indicates the aroma threshold for H_2S (1.1-1.6 µg/L).

Monitoring the development of 'reductive' compounds and assessing the impact of key wine characteristics

A series of benchtop experiments investigated the relative impacts of aluminium (metal) addition, pH increase, oxygen, SO_2 and copper on H_2S and methanethiol (MeSH) levels in a commercial wine at elevated temperature (35°C). This work showed that the impact of aluminium on H_2S formation is lower with higher pH, higher oxygen concentration, decreased SO_2 and lower copper concentration. Minimal effects of these characteristics were seen on MeSH concentration.

Assessing the effectiveness of mitigation strategies for decreasing metals content in wines

Initial attempts to mitigate the development of H_2S in canned wines focused on the use of two commercially available cross-linked polymers (CLPs) to sequester copper and minimise the impact of any aluminium transfer during storage. Results to date show that these CLPs are effective in drastically decreasing copper levels in white and red wines. A more detailed investigation of the forms of copper removed during this process was carried out in conjunction with collaborators at the National Wine and Grape Industry Centre. This showed that these CLPs tend to remove sulfide-bound forms of copper, thereby decreasing the residual concentration of VSC precursor compounds in wines and delaying the onset or decreasing the subsequent concentrations of H_2S.

Smoke taint research

Background

The AWRI, Agriculture Victoria, La Trobe University and Wine Victoria are collaborating on a project funded by Wine Australia, the AWRI and the Australian Government Department of Agriculture as part of its Rural R&D for Profit program. The AWRI's primary role in the project is to evaluate a range of possible remedial management options and processing tools for dealing with smoke-affected grapes and wine. In addition, the project team is collaborating with Agriculture Victoria and La Trobe University to evaluate a range of possible monitoring, preventative and remedial management options and tools for dealing with the variable composition of atmospheric smoke and associated risk of smoke taint in wine.

Smoke taint mitigation studies

Activated carbon

The effectiveness of 14 activated carbon products in fining smoke-affected wine and juice was studied for a range of varieties. Previous studies had been largely limited to red juice and wine due to limited availability of smoke-affected white juice and wine. This year, additional studies were able to be undertaken on 'real' smoke-affected Sauvignon Blanc, Chardonnay, Riesling and Pinot Noir juices and wines sourced in 2018 and 2019. Carbon fining removed up to 80% of smoke glycosides from the Sauvignon Blanc juice; however, removal from wine was more challenging, but found to be more effective in white than red wines (e.g. 40-60% removal compared to 0-10% when dosed at 2 g/L carbon). The effectiveness of carbon fining in removing smoke glycosides in the Sauvignon Blanc juice was also evaluated at various dose rates (0.5 to 2.0 g/L) in the presence of caffeic acid, tannins and volatile phenols, and at different pH levels. Caffeic acid and tannin were found to hinder removal of smoke glycosides, but changes to juice pH or the presence of volatile phenols did not have an impact on glycoside removal.

In preparation for winemaking trials, three activated carbon products were evaluated at 4°C and in the absence of mechanical mixing, with neither of those parameters affecting removal rates. The ability of carbons to remove a higher concentration of glycosides in a white grape juice was also explored, as well as their effectiveness in additional juices with varying degrees of smoke taint. Results indicated

that the adsorption of smoke glycosides by activated carbon is concentration-dependent. Batch to batch variation for three carbon products shortlisted for winemaking trials was investigated. While there was some variation (i.e. up to 10%) in performance, overall the carbon products still showed consistent removal of smoke glycosides. As a result of the benchtop studies, two carbon products were selected for 2019 winemaking trials.

Glycosidases

Glycosidase experiments were undertaken on additional wines. Five commercially available glycosidases were evaluated and found to cleave 60-70% of the gentiobiosides contained within two smoke-affected Cabernet Sauvignon wines, one Sauvignon Blanc and one Pinot Noir wine. Less cleavage occurred for other smoke glycosides. These results mirror other studies where gentiobiosides were also preferentially cleaved. Since the impact on wine sensory properties was not known, a smoke-affected Pinot Noir wine was treated with glycosidases and the resulting wine presented to the quality panel. Glycosidase treatment did not reduce the perception of smoke taint, suggesting that for this to be a feasible remediation option it may need to be performed in conjunction with carbon treatment to remove free volatile phenols. Industry samples of an enzyme-treated smoke-affected Pinot Noir wine were also analysed and similar trends were observed. Two novel glycosidases, (i) *Halothermothrix orenii* (Hal) β-glycosidase; and (ii) *Alicyclobacillus acidiphilus* (Aci) β-glycosidase were evaluated for their abilities to cleave smoke glycosides in two smoke-affected Pinot Noir wines. However, these glycosidases were found not to cleave smoke glycosides in these wines, perhaps a consequence of enzyme inhibition at natural wine pH. Additional enzyme studies have now commenced with smoke-tainted Pinot Noir and Chardonnay wines, with the aim of undertaking larger-scale trials for sensory analysis.

Masking smoke taint

When a suspected tainted Sauvignon Blanc wine with elevated residual sugar (14.4 g/L) was presented to the AWRI's technical quality panel, the panel did not assess the wine as smoke tainted. This raised the question as to whether sugar can mask the perception of smoke taint. To assess this, sugar (14 g/L, 50% glucose, 50% fructose) was added to a smoke-affected Pinot Noir wine which was then presented to the AWRI's technical quality panel. However, in this instance sugar addition did not mask the perception of smoke taint, with the panel finding the wine to be affected by smoke characters.

Vineyard variability

Vineyard variability among grapes exposed to smoke during a 2018 bushfire was assessed across two blocks (one Chardonnay, one Pinot Noir). For the majority of grape samples (90% for Pinot Noir and 100% for Chardonnay), the levels of volatile phenols and smoke glycosides were relatively consistent (within 20% RSD of the mean) and all samples had concentrations of exposure markers above concentrations observed for 'clean' grapes in previous baseline studies.

Winemaking trials

Smoking experiments using Chardonnay grapes (1.6 tonnes) and smoking tents were undertaken in February 2019, yielding approximately 1,000 litres of juice for winery-scale remediation treatment trials. One hundred litres of the artificially smoked juice were fermented into wine, with the remaining juice being held in frozen storage. Fires in February 2019 provided an opportunity to source smoke-affected Pinot Noir and Chardonnay grapes, juices and wines. Winemaking trials were performed with the 2019 smoke-affected Chardonnay and Pinot Noir (rosé style) juices using two activated carbon products at three dose rates (1.0, 2.0 and 4.0 g/L) in duplicate (total of 28 x 50 L ferments including controls). Juices were treated with the carbon products prior to fermentation, with bentonite added to assist in settling after a contact time of 48 hours. The percentages of smoke glycosides remaining in each of the juices after carbon treatment and bentonite settling are shown in Figure 23 and 24. For certain dose rates, carbon product number 14 was slightly more effective at removing the smoke glycosides but it also removed more colour. Furthermore, both carbon products were more effective at removing smoke glycosides from the Chardonnay juice than the Pinot Noir juice; however, the latter did contain higher initial concentrations of total smoke glycosides. Sensory impacts of the treatments on the wines made from the treated juices will be assessed. Larger-scale (200 L) ferments were also undertaken on these juices to produce wines for additional remediation studies.

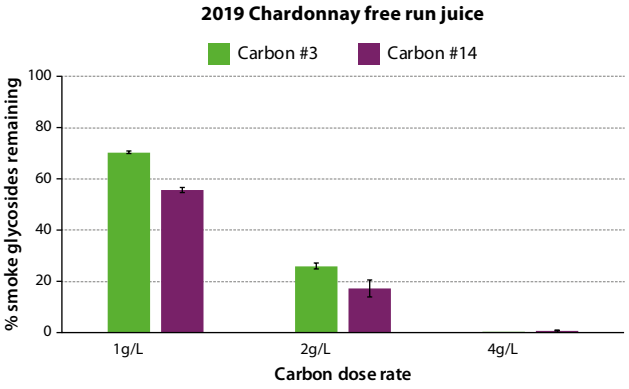

Figure 23. Total smoke glycosides (n=6) remaining in 2019 smoke-affected Chardonnay juice after treatment with two activated carbon products at 1, 2 and 4 g/L for 48 hours and bentonite fining (24 hours). Initial concentration of total smoke glycosides 251 µg/L syringol glucosylglucoside (SyGG) equivalents.

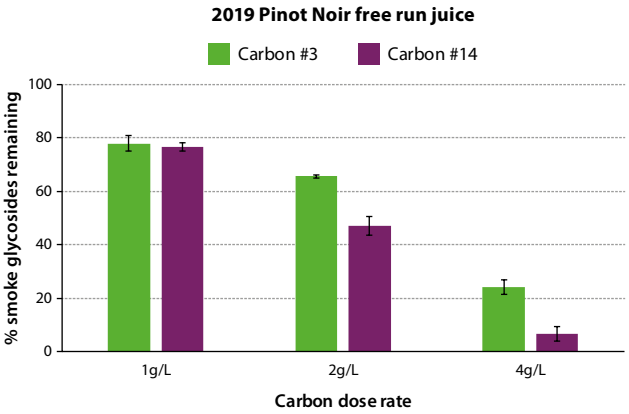

Figure 24. Total smoke glycosides (n=6) remaining in 2019 smoke-affected Pinot Noir juice after treatment with two activated carbon products at 1, 2 and 4 g/L for 48 hrs and bentonite fining (24 hours). Initial concentration of total smoke glycosides 335 µg/L SyGG equivalents.

Collaborative work

The AWRI is collaborating with the University of Adelaide's Industrial Transformation Training Centre on smoke taint research. Assistance was provided for two PhD projects, one investigating whether in-canopy misting can reduce the uptake of smoke molecules in grapes and a second investigating the use of cyclodextrins for mitigating smoke taint in juice and wine.

A collaboration with the University of Adelaide, PIRSA, Grains Producers SA, SA Grains Industry Trust and La Trobe University has commenced to assess the potential impact of smoke from stubble burns on grapes and wine, with funding obtained from the South Australian Wine Industry Development Scheme.

Environment, sustainability and natural capital

The success of the Australian grape and wine industry is strongly tied to its long-term custodianship of the natural environment. Soil, water, biodiversity and climate all contribute to the success or failure of grapegrowing across Australia. Electricity, fuel, refrigeration and waste disposal are all major costs in winemaking. Projects under this theme aim to assist producers to improve environmental and economic performance; to adapt to the challenges of a variable climate; to make the most of the grapevine clonal resources available; to develop tools to verify the origin of Australian wines; and to improve management of pests and diseases.

Staff

Tadro Abbott (to 12 April 2019), Sheridan Barter, Dr Keren Bindon, Dr Anthony Borneman, Kate Cuijvers, Dr Martin Day, Damian Espinase Nandorfy, Dr Leigh Francis, Prof. Markus Herderich, WenWen Jiang, Dr Mark Krstic, Dr Mardi Longbottom, Dr Simon Nordestgaard, Dr Cristobal Onetto, Wes Pearson, Dr Paul Petrie (to 30 November 2018), Song (Luke) Qi (from 5 November 2018), Dr Michael Roach, Steven van den Heuvel (from 5 July 2018), Dr Cristian Varela, Dr Eric Wilkes.

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Managing the impact of vintage advancement and compression

Background

Vintage compression places significant stress on harvest and processing logistics and winery capacity. However, the contribution of management practices (e.g. improved irrigation or pruning) to vintage compression has not been separated from the effect of higher temperatures. In addition, trends in fruit maturity parameters other than sugar accumulation need to be investigated, as does the balance between titratable acidity and pH with sugar concentration.

One important consequence of vintage compression is delays in harvesting fruit and resulting high sugar/alcohol concentrations. Increases in grape sugar concentrations can be driven by the import of sugar from the vine, or by berry dehydration. Dehydration also results in a loss in yield, with a significant impact on vineyard profitability. A better understanding of these factors will inform both winery and vineyard management decisions.

Understanding sugar accumulation by berries

Vintage compression can lead to a delay in harvest and fruit being picked with higher than ideal sugar concentrations and less desirable flavour characteristics. To help avoid fermentation problems with high-sugar grapes, FSANZ regulations now allow the pre-fermentation dilution of must to 13.5°Baumé. By establishing a lower limit for sugar concentration, this has shifted the focus towards the mass of sugar produced, in addition to the mass of grapes harvested. Under the revised regulations, knowing the point when sugar movement into the fruit ceases becomes an extra parameter to consider when optimising harvest decision-making, along with fruit maturity and flavour profile. While other key quality parameters such as acids, anthocyanins and phenolics may change as 'hang time' is extended, potentially improving the quality of the final wine, it is important to recognise that the further increase in sugar concentration in the fruit is due to dehydration of the berries. However, as grapegrowers are paid based on the yield of grapes, conflict may occur between growers and wineries when high sugar concentrations occur due to fruit dehydration as opposed to the importation of sugar into the grapes.

The goals of this work were to conduct a meta-analysis of studies on grape ripening across Australian growing regions for Shiraz and Cabernet Sauvignon, to determine the range of sugar concentrations (and specifically the maximum) at which sugar accumulation ceases. Boundary layer regression was used to determine the maximum sugar concentration where the sugar content per berry stopped increasing. For Shiraz this was 13°Baumé and for Cabernet Sauvignon it was closer to 14.5°Baumé. The information will serve as guide to producers of these varieties to predict when fruit dehydration is likely to occur and to help optimise the decision on when to harvest grapes.

Can dilution of grape must address the effects of vintage compression without a loss of wine quality?

The revised FSANZ regulations allow must to be diluted with water to a minimum of 13.5°Baumé. The rationale behind this change was to reduce the chances of problems arising during fermentation; however, an additional benefit may be to help industry manage the logistical problems caused by compressed vintage periods. To help understand the effects of dilution on wine composition and quality, a study was

conducted using Chardonnay grapes sourced from the moderate to warm region Currency Creek in SA. Chardonnay was harvested at 14.5 and 15.5°Baumé and diluted to 13.5°Baumé using direct addition of rainwater to the must. An earlier harvest at 13.5°Baumé was included for comparison. Sensory assessment showed that differences between the wines were small, with the main attribute affected by dilution being hotness. Hotness was similar between the 13.5 and 14.5°Baumé control wines, and the diluted 14.5°Baumé treatment. Not surprisingly, the 15.5°Baumé wine was rated highest for hotness. However, it was interesting to note that the diluted 15.5°Baumé treatment had the lowest perceived hotness, despite having a similar alcohol concentration to the reference treatments. Various sensory attributes were assessed for the wines such as 'confection' aroma, 'stone fruit' flavour and 'citrus' flavour, but these were not significantly different among the wines. Only yellow colour was found to increase significantly with ripening, and was highest in both the diluted and control 15.5°Baumé wines. These preliminary results show that water addition may be used for Chardonnay, in accordance with the FSANZ regulations, without significant negative impacts.

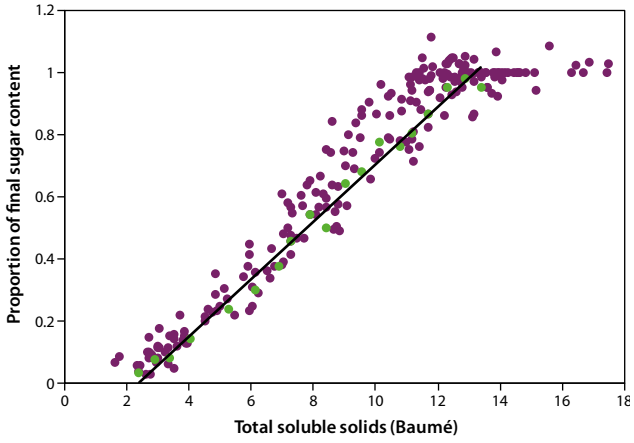

Figure 25. The relationship between the sugar concentration (Baumé) and proportion of the berry sugar content for the final sample in each series (for Shiraz). Purple points come from maturity curves collected from research articles, green points are the 10th percentile for each 0.5°Baumé range as used for the boundary layer regression. Where the regression line reaches 1 is approximately where sugar accumulation has stopped.

Damian Espinase Nandorfy

Supporting the sustainability of grape and wine businesses and Australia's sustainability credentials

Background

In 2019, Entwine Australia reached a significant milestone: ten years as the Australian wine industry's endorsed national sustainability program. Entwine was the principal vehicle to convey the Australian wine industry's sustainability credentials over that period. The program delivered tools and resources to help grape and wine businesses manage the different aspects of sustainability. The structure, content and strategic direction of Entwine were guided by industry reference groups.

Implementation of Sustainable Winegrowing Australia

In 2018, the recommendations from the global sustainability review were synthesised in an implementation plan for the delivery of a single, united national sustainability program. The plan was agreed by the AWRI, Australian Grape & Wine and Wine Australia and activities commenced at the end of 2018. In February 2019, Wine Australia facilitated a workshop with representatives from all states and different business types and sizes to define the value proposition of the united program and to consider potential names. The consensus within the workshop group was that the name needed to be descriptive of what the program is and does – hence Sustainable Winegrowing Australia. Sustainable Winegrowing Australia will be overseen by a steering committee with representatives of Australian Grape & Wine, Wine Australia and the AWRI, with support from a Sustainability Advisory Committee made up of program users, regional representatives and other key stakeholders. The program will continue to be administered and supported with technical resources by the AWRI.

In the lead-up to the official opening of Sustainable Winegrowing Australia on 1 July 2019, the content and memberships of the Entwine and Sustainable Australia Winegrowing programs were merged and the certification materials were reviewed and updated to develop the draft 'Australian Wine Industry Standard of Sustainable Practice'. The AWRI invested in a new online database to manage the membership, data and reporting for Sustainable Winegrowing Australia.

Industry engagement with Sustainable Winegrowing Australia has been strong and feedback from industry meetings and regional presentations has been positive. A trust mark and clearer direction on the marketing of sustainability are key elements for some segments of the Australian grape and wine industry. These areas will be considered by the steering committee in tandem with program uptake.

Sustainability and business resilience

As a follow-up from a 2017 pilot study which investigated the unique features of sustainable Australian wine-grape vineyard businesses, in 2018 the AWRI partnered with the Queensland University of Technology and National Australia Bank through the Food Agility CRC in a project that aims to quantify the relationship between environmental and economic performance. A literature review was performed to identify the most appropriate financial metrics to be included in the annual data collected through Sustainable Winegrowing Australia in 2019. Once the financial data is collected, further modelling will be undertaken and members who submit economic data will be able to benchmark their performance against aggregated data provided by other members.

Defining regional variability and uniqueness of premium Australian Shiraz

Background

This project aims to define sensory properties of Shiraz wines from several regions that contribute to distinctive regional character, and to provide objective compositional markers for both grapes and wine for future use in vineyard and winery assessment. The project is part of a collaborative study with Charles Sturt University.

Chemical measures that relate to regional sensory differences

As previously reported, detailed sensory examination of a large number of commercially produced wines from six regions, namely Barossa Valley, McLaren Vale, Heathcote, Yarra Valley, Canberra and the Hunter Valley, was completed. This work involved characterising wines from each region, selecting representative examples, and then quantifying their sensory attributes as a set. There were numerous sensory attributes that separated the wines across the regions. The sensory data were related to almost 70 targeted compositional measures using multivariate regression techniques. The models generated were able to predict most attributes well, with, unusually in this type of exercise, no wines flagged as outliers or as strongly influential samples in the regression models. This reflects the fact that multiple wines representing the range of wine styles from the regions were included, with a good spread across the multivariate space.

Key compounds were identified as major contributors to sensory attributes, some of which had been tentatively identified in previous studies, with others indicated for the first time. Grape-derived compounds such as beta-ionone and beta-damascenone, as well as several fermentation-derived acetate esters, were highlighted as particularly critical to 'red fruit' and 'dark fruit' characters, while some monoterpenes also featured in the models. Known impact compounds such as isobutylmethoxypyrazine and rotundone were related to 'green capsicum' and 'pepper' attributes respectively, while mouth-feel and textural characteristics were also modelled well.

Results will be confirmed in a follow-up sensory reconstitution study, and once targets are confirmed, industry practitioners will be able to better control distinctive attributes related to regional differences through viticultural and winemaking adjustments.

Development of tools to verify origin and varietal nature of wines

Background

Wine is periodically the subject of substitution or counterfeiting. This project aims to protect the reputation of Australian wine by developing a robust way to determine the provenance of an unknown wine sample using several isotope ratios and a matrix of elemental concentrations. The initial promising results achieved using strontium isotope ratios have been improved in conjunction with project partners at CSIRO, with the inclusion of data on the isotope ratios of boron, lithium and lead.

Is it Australian?

The focus of the most recent work has been on expanding the data set of Australian wines to include as many regions as possible and increasing the range of isotopic ratios for each wine to include those for boron, oxygen, lithium and lead. These extra isotopic ratios were chosen as literature had suggested that they had some potential to be related to the provenance of wine. The final data set was expanded to include 292 wines from around Australia and more than 90 wines from other countries.

Figure 26 shows that the boron, oxygen and strontium isotopic ratios have an inherent ability to separate Australian wines from overseas wines.

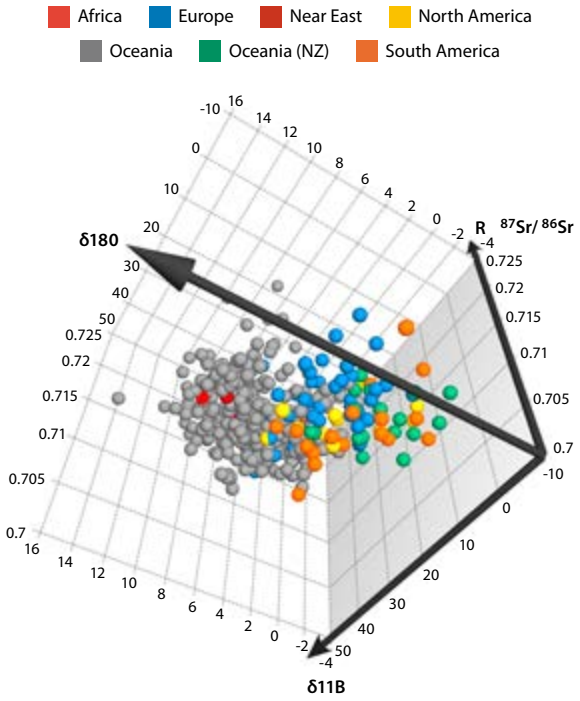

Figure 26. Isotope ratios of B, O and Sr coloured by continent of origin (no statistical treatment, n=386)

A principal component analysis using all available isotopic ratios, however, led to differentiation of red and white wines (Figure 27). This was undesirable as it suggested that the differences in winemaking processes between red and white wines were introducing differences in the isotopic ratios, masking the signals from the grape origins. Further study of these effects showed that the main driver of the differentiation was the lead isotopic ratios, which could be traced back to lead introduced into white wines by bentonite fining for protein stabilisation. This result ruled out further use of lead isotopic ratios in the study.

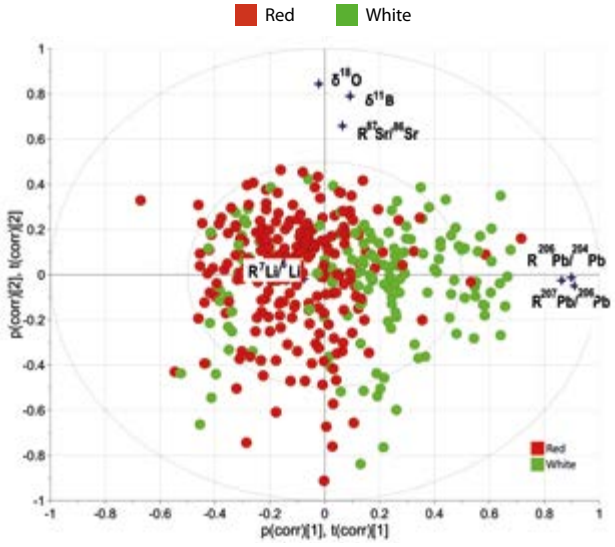

Figure 27. Principal component analysis using the isotope ratios of B, Pb, Li, O and Sr, coloured by grape type (red or white)

In a similar vein it was decided to investigate if there was any possible contribution of boron from the glass in the wine bottles to the isotopic variation for this element found in wine. Flint and green glass bottles were sourced from different countries and wine was stored in them to elucidate any impacts. No significant differences were seen in the wine stored in bottles from different continents, suggesting that the bottle source had little impact.

Using the strontium, lithium, boron and oxygen isotopic ratios with a statistical technique called orthogonal projection of latent structures-discriminant analysis (OPLS-DA) it was possible to differentiate Australian wines from those produced overseas without any contribution from wine processing factors (Figure 28).

Australian regionality

Using similar approaches, it was also possible to classify Australian wine (regardless of grape colour) based on subsoil types, although detailed discrimination of regionality would likely require detailed studies of more wines from each region and perhaps the inclusion of additional data such as trace metal concentrations.

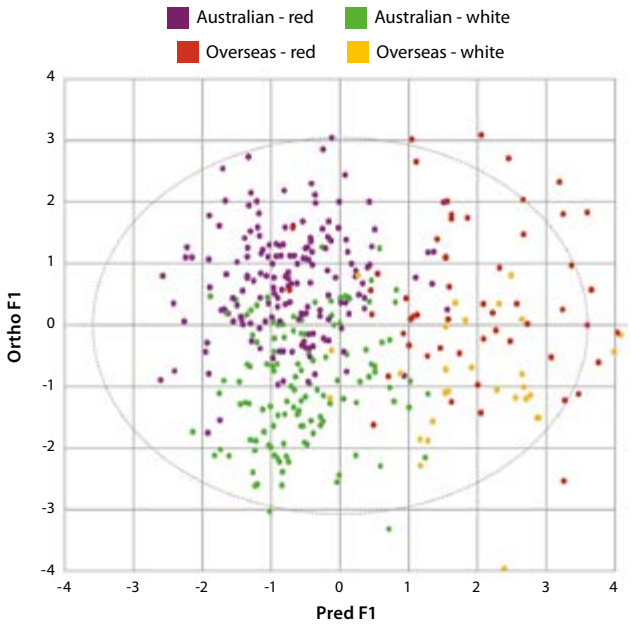

Figure 28. Orthogonal Projection of Latent Structures–Discriminant Analysis (OPLS-DA) using the isotope ratios of B, Li, O and Sr, classified by origin (Australia/overseas) and coloured by grape type (red/white)

Bioprospecting Australian microbial genetic diversity

Background

Differences in wine microbiota are likely to be an important aspect of terroir, particularly where spontaneous fermentations are performed. Traditional microbiological research has shown that both vineyards and uninoculated wine fermentations contain diverse mixtures of microbial species, often with species being represented by multiple strains. However, the inability to efficiently and accurately assess the large numbers of samples required to understand such a complex concept as terroir has limited further insights into this important area. This lack of information is also an impediment to the exploitation of native microbial germplasm and spontaneous fermentation by the Australian wine industry. Recent advances in culture-independent microbiological techniques such as metagenomics (genomic sequencing of mixed microbial communities) can address these issues by efficiently providing detailed identification of the species, and their proportions, in complex microbial mixtures.

Microbial composition of wild ferments

More than 2,000 samples from uninoculated ferments were analysed from 34 wineries around Australia across the 2016-2018 vintages. This data source is now providing information on the microbial variability that can occur across vintages in addition to that seen between different wineries or even between ferments performed in the same winery.

Winemaking trials investigated the potential effects of common winemaking interventions on the microbiota of uninoculated ferments. Different SO_2 and oxygen supplementation regimes produced significant effects on the wild yeast population of fermenting must. The effects of these different microbial communities on the chemical composition of the finished wine are now being determined to assess the potential impacts of changing yeast population dynamics on the sensory properties of wine.

Bioprospecting

Almost 10,000 yeast isolates (*Saccharomyces* and non-*Saccharomyces*) have been added to the AWRI Wine Microorganism Culture Collection over the course of this project. These yeast strains provide a valuable genetic resource that is currently being mined for the next generation of commercial wine yeast strains for the Australian wine industry. A range of high-throughput assays have been developed to rapidly screen this large collection to identify individual wine yeast isolates that display a mix of characteristics that make them suitable for further investigation as future commercial yeasts.

Rotundone and its role in defining terroir in iconic Australian cool climate 'peppery' Shiraz

Background

Rotundone is the potent, grape-derived compound responsible for 'black pepper' aroma in wine. Previous research demonstrated that the Grampians and Pyrenees regions in Victoria can produce wines with substantially higher levels of rotundone than other Shiraz-producing regions such as Barossa and McLaren Vale. Patterns of rotundone variation appear to be stable within an individual vineyard across different growing seasons. A new collaborative project with CSIRO commenced in 2017, focusing on premium cool climate Shiraz, that aims to define features at the within-vineyard scale that contribute to rotundone formation. The research seeks to identify genetic and biophysical factors responsible for large differences in rotundone concentrations at harvest, and will provide insights into how the rotundone element of terroir, and grape aroma in general, may be influenced and managed at a range of scales.

Grape aroma compounds in cool climate Shiraz

GC-MS analysis of rotundone and α-guaiene in samples collected in 2018 in the Adelaide Hills showed a similar range of concentrations to those observed in the same vineyard in 2017. Mapping of α-guaiene in samples collected in 2017 and 2018 from this vineyard showed that the structure and patterns of spatial variability in α-guaiene were, for all practical purposes, the same as for rotundone. This is consistent with the view that α-guaiene is the precursor to rotundone in grapes. Again, rotundone formation in grapes occurred only relatively late in the ripening season, as had been observed previously in the Grampians. This suggests that grape rotundone concentrations and 'peppery'

attributes in wine can be influenced by harvest timing, with earlier harvest reducing the likelihood of obtaining 'peppery' aromas and late harvest increasing the likelihood of such characters.

In addition, existing GC-MS data sets were re-analysed using bioinformatics tools for non-targeted profiling of grape volatiles. Spatial analysis and mapping of metabolites identified through this metabolomics approach showed that the structure and pattern of spatial variability of a range of sesquiterpenes is, for all practical purposes, the same as for rotundone. However, the 2018 rotundone and sesquiterpene maps from the Adelaide Hills vineyard were substantially different to the 2017 maps. This suggests that both the synchronised induction of sesquiterpene biosynthesis (by environmental trigger(s) which may vary from year to year) and the availability of precursor α-guaiene are key to explaining grape rotundone concentrations.

The role of site characteristics in defining grape aroma compounds

A ripening experiment was conducted in 2019 to assess the impacts of harvest timing and extended hang-time on grape rotundone concentrations. In addition, vineyard experiments in the Grampians and Adelaide Hills regions were repeated in the Eden Valley to corroborate earlier observations.

Analysis was conducted to assess the role of microbial populations in vineyard soils, soil composition and soil attributes in shaping grape rotundone concentrations. Specifically, soil samples underwent chemical analysis, DNA samples were prepared and submitted to amplicon sequencing for bacteria (16S) and fungi (ITS) community composition, and metagenomic analysis of sequencing was completed for a vineyard in the Grampians region. The results were summarised in an article published in *Frontiers in Microbiology* (Gupta et al. 2019). In short, metagenomics analysis of surface soil samples collected from the previously identified high- and low-rotundone zones showed marked differences in the genetic diversity and composition of the soil bacterial and fungal microbiomes; a few specific taxa/groups of microorganisms were associated with the rotundone-based variation; and bacterial communities in soil from the high-rotundone zone appeared to form a much more complex and connected network than those in the low-rotundone zone soils. Also, short-term mulching effects did not seem to mask this rotundone zone-based variation.

Reference

Gupta, V.V.S.R., Bramley, R.G.V., Greenfield, P., Yu, J., Herderich, M.J. 2019. Vineyard soil microbiome composition related to rotundone concentration in Australian cool climate 'peppery' Shiraz grapes. *Front. Microbiol.* 10: 1607.

Understanding the basis of agrochemical resistance in biotrophic grapevine pathogens

Background

Grapevine diseases caused by fungal/oomycete pathogens such as *Botrytis cinerea, Erysiphe necator* (powdery mildew) and *Plasmopara viticola* (downy mildew) are responsible for significant crop losses. Current control measures rely on spraying with agrochemicals; however, the development of resistance to agrochemicals is an ever-increasing problem in agriculture, and one from which the Australian wine sector is not immune.

Improving the understanding of agrochemical resistance in powdery mildew

Previous research showed that known resistance mutations to many commonly used agrochemicals are prevalent in both powdery and downy mildew. However, it is not yet fully understood how the presence of the mutations relates to loss of field efficacy for key agrochemicals. This is an important question to be answered before genetic tests can be used to inform viticultural practices. The AWRI is applying next-generation sequencing to map the prevalence of known resistance mutations in laboratory-based populations of powdery mildew being studied by SARDI researchers. These experiments aim to shed light on the relationship of the mutations with the development of field-relevant levels of agrochemical resistance, such that a genetic test can be used to help growers make decisions about agrochemical use.

Genetic basis for metalaxyl resistance in downy mildew

While the molecular basis of resistance is well known for many agrochemicals, there remain agrochemicals for which targets are not known. This includes metalaxyl (the key control measure for downy mildew), for which field resistance is readily observed but the genetic cause is not known and therefore a genetic test for resistance is not available. Genome sequencing and assembly were performed on five downy mildew strains isolated from around Australia to provide a baseline measurement of genetic variation across this species.

Viticulture biosecurity support

Background

The AWRI delivered biosecurity management activities on behalf of Australian Vignerons (AV) from July to November 2018. As a signatory to the Emergency Plant Pest Response Deed, AV had a national responsibility for biosecurity arrangements in the wine sector and undertook this responsibility in close association with the Winemakers' Federation of Australia (WFA), Wine Australia and other agricultural industries. From November 2018 to February 2019, AV managed its biosecurity activities in-house and, following its merger with WFA to form Australian Grape & Wine (AGW) in February 2019, biosecurity activities were managed by AGW.

Technical support

AWRI viticulture staff provided technical support to AV in meetings and activities of the Consultative Committee for Emergency Plant Pests (CCEPP) and the National Management Group (NMG). They also provided secretariat services for the National Viticulture Biosecurity Committee (NVBC). Two AWRI staff members provided in-kind support to review a Wine Australia-funded project, 'A comprehensive review of Pinot Gris Virus'.

Catherine Borneman, Fang Tang

Foundational data and support services

The research, development and extension activities of the AWRI are underpinned by an efficient service capacity that provides and supports infrastructure; delivers research support and analytical services; manages governance, legal and financial affairs, information technology and workplace safety; and monitors trends in Australian wine composition and production practices.

Staff

Tadro Abbott (to 12 April 2019), Melissa Aitchison (to 31 December 2018), Sheridan Barter, Ida Batiancila, Linda Bevin, Laura Bey, Eleanor Bilogrevic, Catherine Borneman, Mark Braybrook, Natalie Burgan, Alfons Cuijvers, Chris Day, Dr Zung Do, Shiralee Dodd, Damian Espinase Nandorfy, Dr Leigh Francis, Josephine Giorgio-Ion, John Gledhill, Robyn Gleeson, Dr Nuredin Habili, Jesse Hall, Thomas Hensel (from 2 October 2018), Prof. Markus Herderich, Kieran Hirlam, Dr Josh Hixson, Adam Holland, Leanne Hoxey, Dr Vilma Hysenaj, Dr Dan Johnson, Pauline Jorgensen, Dr Mark Krstic, Jillian Lee, Desireé Likos (from 14 January 2019), Dr Natoiya Lloyd, Brigitte Lynch, Jacinta McAskill, Bryan Newell, Dr Luca Nicolotti, Dr Simon Nordestgaard, Jennifer O'Mahony, Kara Paxton (from 12 November 2018), Wes Pearson, Lisa Pisaniello, Tim Reilly (to 31 December 2018), Dr Amy Rinaldo, Ella Robinson, Marco Schoeman, Neil Scrimgeour, Dr Tracey Siebert, Pamela Solomon, Fang Tang, Dr Maryam Taraji, Randell Taylor, Deborah Thornton-Wakeford, Heather Tosen, Kylee Watson, Dr Matthew Wheal, Dr Eric Wilkes, Dr Patricia Williamson (to 12 November 2018), Qi Wu, Amanda Ylia.

Collaborators

AB Biotek (Dr Tina Tran); Australian Institute for Bioengineering and Nanotechnology (Dr Esteban Marcellin Saldana); Compusense, Canada (Ryan Corrick); CSIRO (Peter Clingeleffer); Murdoch University (Assoc. Prof. Robert Trengove); Lion (Jarret Rigg); Queen Victoria Museum & Art Gallery (David Thurrowgood); SARDI (Dr Marcos Bonada); University of Adelaide (Assoc. Prof. Paul Grbin, Assoc. Prof. Cassandra Collins); University of Melbourne (Prof. Ute Roessner, Prof. Malcolm McConville); University of Western Australia (Assoc. Prof. Michael Clarke).

Visiting researcher

Dr Marc Pignitter, University of Vienna, Austria.

Efficient administration

Background

The AWRI's management and administration is carried out by a dedicated team of specialists who work together to efficiently and effectively provide leadership, infrastructure, financial, human resources, legal, contract management, risk management, work health and safety, corporate governance and IT services across the organisation. The team's objective is to enable all AWRI staff to focus on their core capabilities to ensure that the organisation is able to meet its objectives, and in turn the expectations of its stakeholders. The team works closely with the AWRI Board, which provides additional leadership and oversight to all AWRI activities.

Finance

Core activities included financial management; budgeting; and reporting to the AWRI's management and Board, funding organisations (particularly Wine Australia) and various arms of government. Back office support was also provided to entities such as the Australian Wine Industry Technical Conference, Interwinery Analysis Group and the Wine Innovation Cluster, including its Crush symposium. Other notable activities included an external review and strengthening of controls mitigating the risk of social engineering fraud, the implementation of a new expense management platform for the use of all staff and the further leveraging of the organisation's charitable status to secure relief from certain credit card interchange fees. The AWRI's diversified investment portfolio continued to generate an appropriate level of return, underpinning the organisation's ability to further invest in critical capabilities and activities to support the Australian grape and wine industry. During the year similar diversified portfolios were also implemented for the assets of the four memorial trusts for which the AWRI acts as unrewarded trustee, to generate higher levels of return (in a risk-appropriate manner) with which to achieve the trusts' objectives.

Human resources

This capability maintains responsibility for a broad range of functions including recruitment, employment contract management, visas, payroll and compliance activities. In 2018/2019 a new platform for leave management was tested and implemented. AWRI staff received group training in mental health first aid, management skills, preparing posters and delivering presentations in addition to numerous individual professional development activities. Many of the AWRI's directors make a substantial contribution to these activities by nominating for their directorship fees to be made available for such purposes, and their support is gratefully acknowledged. The annual staff survey once again highlighted the AWRI's positive working environment, with more than 90% of respondents confirming that 'all things considered, the AWRI is a great place to work'. Themes which consistently contribute to this outcome include the diversity of work, the collaborative, productive and passionate workplace culture and close engagement with industry.

Operations

Cost-effective custom-designed and manufactured engineering solutions were provided to support a range of AWRI projects. Recent examples included experimental equipment for 'smoke tainting' wine-grapes, gas-dosing equipment for pilot- and commercial-scale fermentations, installation of supporting infrastructure for new instrumentation and refurbishment of a bottling line used to package research wines. Broader activities involved developing solutions to space constraints faced across the AWRI's laboratory, office and storage environments, including modifications to the AWRI's premises to enhance storage capacity for frozen materials and bottled research wines, reconfiguration of a number of office environments and the securing and fit-out of an off-site storage facility.

Corporate governance and legal support

Key activities this year included conducting a periodic internal review of the Board and its processes, arranging work health and safety and corporate governance update sessions for the Board while maintaining good corporate governance practices in relation to risk management, policy review and contract management.

Information technology

This year saw the completion of the first IT Strategic Plan – on time and on budget – and the development and subsequent approval of the next IT Strategic Plan for the period 2019 to 2021, supported and enabled by the IT Strategic Reserve previously created by the AWRI Board. The plan includes such initiatives as the upgrade of the entire core network infrastructure, increasing security by implementing multi-factor authentication, improving remote access procedures and real-time monitoring, local back-ups of cloud data and physical/virtual server upgrades. Such enhancements continue to add considerable value to almost every aspect of the AWRI's operations.

Information and knowledge management

Background

Knowledge is at the core of the AWRI's operations and an effective information and knowledge management (IKM) environment is therefore essential to support the AWRI's core business. This project provides a flexible and agile IKM environment, which supports innovation and excellence at the AWRI. This is being achieved through harmonisation of existing IKM platforms and the information they contain; the adoption of emerging IKM technologies and solutions; improving access and collaboration capabilities; and the optimisation of business processes through the use of automated workflows.

Implementation of SharePoint Online

The creation of SharePoint sites to manage projects and team operations was completed in 2018/2019, enabling teams to share project and operational documents within the AWRI and with external collaborators. One of the key advantages of this cloud-based system is the ability for staff and collaborators to access files from anywhere and at any time.

An online portal for AWRI Board members to access Board papers electronically was made available this year. This initiative has improved the process of preparing Board papers by eliminating the need to print and distribute hard copies of Board papers to directors.

Commercial Services

Background

AWRI Commercial Services continues to serve an important role in the Australian grape and wine industry, providing internationally recognised and accredited reference laboratory services, proof-of-performance testing, consulting services, microbiological auditing and the design and implementation of trials and research for industry, covering all parts of the production chain from viticulture to packaged wine. Commercial Services also continues to be actively involved in pre-competitively funded research projects in applied areas and provides services to the broader agricultural industry and producers of other foods and beverages.

Commercial testing services continue to grow

The Commercial Services laboratories had another record-breaking year in terms of services provided, with the laboratories processing more than 27,000 samples for the first time, an increase of more than 7% from the previous year. This was underpinned by a continued increase in customer base, with 183 new customers added during the year. This continued growth highlights the value placed by the Australian industry on the services offered, as well as the importance of a centralised accredited laboratory capable of supplying both highly specialised analytical technologies and more general analysis for smaller producers and those that need internationally recognised certificates of analysis. Revenue from Good Laboratory Practice (GLP)-based residue studies continued to grow, increasing by 34% from the previous year and now representing nearly 30% of overall revenue from trace analytical services. The virus testing and elimination services introduced 18 months ago have also seen positive growth as industry interest in this area and awareness about biosecurity in general have increased.

A new direction for biological testing

In recent years the growth of molecular techniques in microbiological testing has seen a significant shift away from simple plating and identification based on morphology for wine and other beverages. The availability of these advanced forms of testing and an increased awareness of the importance of biological aspects of grapegrowing and winemaking has significantly increased the resources required to service industry needs. To cater for this, a new team has been created within AWRI Commercial Services called Applied Biosciences. This team, led by Dr Amy Rinaldo, will encompass all current microbiological testing, virus testing and elimination, site and bottling line audits and new molecular-based testing services.

The Applied Biosciences team has continued to expand offerings to the brewing industry, introducing two molecular-based assays relating to foam stability. These are an enzyme assay which quantifies proteinase A activity, an enzyme associated with decreased foam stability, and an ELISA assay to quantity LTP1, a foam-positive protein. In wine-related services, the team has also introduced a swab sterility test for bottling lines to use when carrying out in-house microbiology audits and for routine quality assurance checks.

This team will commence a project in 2019/2020 that aims to better understand the real risk of microbiological contamination in bottled wine to help ensure that testing regimes are realistic and effective and are not unreasonably limiting wine production and distribution. This project will develop a comprehensive risk matrix for different typical wine microbiological contaminants and the levels at which they are likely to cause real issues in wine.

Ensuring quality and throughput

A new electronic content management system was implemented, enabling the Trace Analysis team to continue to provide services as an analytical test site for GLP-compliant residue studies. This important software helps to provide a robust chain of evidence when providing data on the levels of residues of pesticides and herbicides that are being evaluated for use in the Australian market.

The Trace Analysis team also added a new gas chromatography-tandem mass spectrometer instrument. The addition of this instrument has improved resources for agrochemical residue analysis and provided the laboratory with an increase in capacity for GLP-compliant residue analysis, helping to ensure fast turnaround times for grapes and wine. The Analytical team also upgraded their sequential analysis instruments to increase redundancy and improve throughput. This same instrumentation is now used for both SO_2 analysis and enzymatic testing, ensuring that at times of peak demand, instrument failure will not adversely affect response times for industry.

Providing confidence to industry

AWRI Commercial Services continues to provide a range of technical performance services to the Australian wine industry, to ensure that new technologies and products are fit for purpose and meet the expectations of the final users. During 2018/2019, trials were carried out on a range of products and technologies, including new technical closures, barrel treatment processes and winery additives. This included an extensive trial assessing the efficacy of potassium polyaspartate in achieving tartrate stability in wines. This study has shown that commercially available products are capable of achieving tartrate stability across white, rosé and red wine styles. Potassium polyaspartate was approved for use in Australia as a winemaking additive in February 2019. A detailed study of the effects of a new barrel treatment process highlighted the potential to impart important volatile aroma and flavour compounds from fortified spirits during the cooperage process. This multi-faceted study included volatile aroma profiling, oak flavour characterisation, detailed colour profiling and sensory descriptive analysis to classify the impact of the technology, which has broader potential for the brewing, wine and spirits industries.

Another new applied project is a major study investigating ways to improve the shelf life of wine and wine products in cans. The study has been initiated with significant funding from both industry partners and the Government of South Australia and to date has identified a number of possible strategies to extend shelf life as well as identifying some issues with the cans themselves. A summary of the key outcomes from this study is provided earlier in this report.

Leveraging information

Efforts to mine the large data sets developed by AWRI Commercial Services during routine analysis of wines have continued during the year with the most recent trends in pH, titratable acidity, alcohol, sulfur dioxide and sugar being collated (see Figure 29 for titratable acidity data). This information is being brought together with earlier studies to better understand Australian wine composition and potential issues that may arise in wine markets and will be submitted for publication in a peer-reviewed journal in the coming year.

Increasingly this kind of data is becoming an important reference, with agencies such as the Australian Bureau of Statistics turning to the AWRI for reliable information on areas such as trends in typical levels of alcohol. AWRI Commercial Services also provided survey data to Wine Australia and the peak industry bodies on iprodione, chlorothalonil and glyphosate, which had been highlighted as concerns in certain markets, posing a potential risk to the continued free trade of Australian wine. The ability to quickly and efficiently provide such data gives Australian peak bodies and government a significant advantage in being able to respond to regulatory issues in export markets before they affect the export of Australian wine.

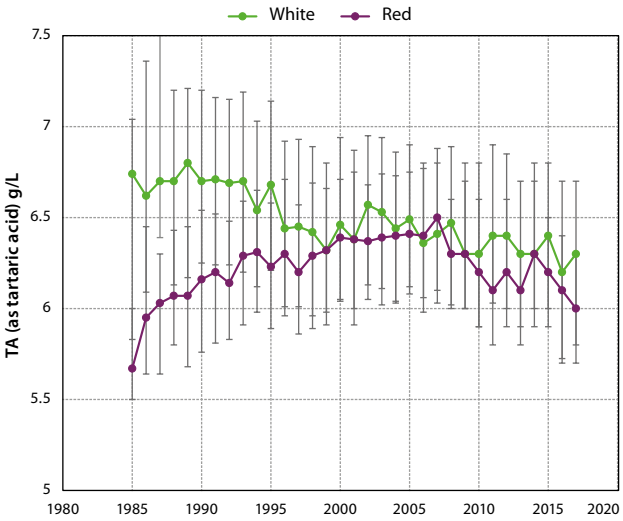

Figure 29. The median titratable acidity found for Australian wines from 1985 to 2017 (error bars indicate quartile ranges)

Research services

Background

The provision of complex analytical equipment and highly specialised methods is a basic element of modern scientific research. This project ensures access to expertise such as sensory analysis, organic synthesis of rare compounds, statistical analysis and running of advanced chemical analytical instruments.

Sensory analysis

A total of 22 major sensory studies were completed, mainly using quantitative sensory descriptive analysis but with some studies involving the more rapid projective mapping methodology. These included assessment of wines made from Shiraz and Chardonnay vines treated with foliar sulfur and nitrogen sprays; a study investigating the effect of whole bunch fermentation on Pinot Noir and Shiraz; a study exploring non-*Saccharomyces* yeast strain effects on Cabernet Sauvignon wines; a water addition study on Chardonnay; and closure and packaging studies. These studies used the AWRI's highly trained and experienced dedicated sensory panel. In 2018/2019 five new members of the panel were recruited and trained, following sensory screening tests.

Twenty-nine triangle test sessions were completed for a range of projects, including a sooty mould study. Thirty-eight technical quality panel sessions were completed, predominantly for helpdesk investigations.

Tablet computers using the sensory data acquisition software Compusense were used exclusively, allowing the discontinuation of expensive hardware. The tablets were used in all sensory sessions,

Nuredin Habili, Qi Wu

including preliminary bench tastings, eliminating use of paper ballots and manual data entry/transcribing of notes. The ability to complete projective mapping and Pivot© Profile sensory tests was also expanded using the tablets.

Synthetic organic chemistry

A stocktake of reference compounds was completed and plans for a dedicated storage facility in the AWRI building were developed. Purification of some flavour compounds was completed, with sample purity confirmed.

Aroma compound analysis

A new gas-chromatography-mass spectrometry instrument was purchased and commissioned to expand capabilities for quantitative volatile analyses.

Development activities

Two aspergillopepsin enzymes were sourced from overseas suppliers, and are being screened for regulatory compliance. Ongoing support in experimental design and analysis is being provided to PhD projects in the ARC Training Centre for Innovative Wine Production.

WIC Winemaking

Background

Wine Innovation Cluster (WIC) Winemaking Services is based at the Hickinbotham-Roseworthy Wine Science Laboratory and is a joint venture between the AWRI and the University of Adelaide that was established in 2010. Its location within the University of Adelaide's purpose-built small-lot and pilot-scale winemaking facility enables the delivery of high-quality research and small-scale commercial winemaking services.

2019 vintage

WIC Winemaking Services processed 451 (6-150 kg) batches of wine during the 2019 vintage, 56% white wines, 44% red wines. Frozen juice and must will be used for a further 10-12 ferments and 63-72 agrochemical studies in the second half of calendar year 2019. The 2019 vintage began slowly with the first fruit arriving in early February; however, excessive heat in late February saw sugar accumulation spike in the first week of March resulting in a frenzy of harvest decisions. On 6 March 2019, WIC Winemaking Services received 37% of its annual fruit intake in one day. Baumé readings were extremely high and pH and titratable acidity levels were also high, making it difficult to achieve desired compositional targets in some cases.

Fruit from all regions was affected by the heat; however, producers that did not rush into harvest and applied irrigation water and waited for the vines to begin functioning again benefited from that decision. Grapes picked in late March and early April showed greater balance sensorially and had better compositional parameters to work with. The last press was on 28 April, two days earlier than 2018. Grapes were sourced from all South Australian regions.

This year WIC Winemaking Services expanded its services to include a capability to produce bottle-fermented sparkling wine. A total of 480 bottles of Chardonnay, 16 bottles each of 30 different trial parameters, are currently undergoing secondary fermentation in bottle. Cross-flow filtration technology is being upgraded and is providing filtration solutions for a wide range of substrates with minimal losses, crucial to small-batch winemaking.

Jacinta McAskill

Metabolomics and bioinformatics service platforms

Background

The AWRI established the South Australian node of Metabolomics Australia (Metabolomics SA) in 2008 as part of a national network with partners in Western Australia, Victoria, and Queensland. Metabolomics SA operates as a collaborative service platform that provides public and private researchers and industries with support, service and training as well as access to infrastructure and specialist expertise.

After a successful external review in 2018, Metabolomics SA secured substantial new investment to support its operations. Bioplatforms Australia, which manages funding through the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), together with the South Australian Government and the AWRI announced a collective investment of $11.1m for metabolomics and associated activities at the AWRI from 2019 to 2023. Funds will be used to replace in-demand mass spectrometry instruments and develop new capabilities in high-resolution mass spectrometry and NMR spectroscopy for non-targeted metabolomics.

Metabolomics services

In 2018/2019 Metabolomics SA successfully completed 59 jobs for clients from a range of sectors. The number of samples analysed for external clients equated to two-thirds of the total amount of work completed. The facility's service portfolio was expanded to include accurate quantitation of plant hormones (gibberellin); vitamin K2 screening; accurate quantitation of tryptophan metabolites; quantitation of ethylene (plant hormone) emissions in rice and wheat; and herbicide product screening.

Services were conducted across food and beverage, agriculture, biomedical and material science sectors. Monitoring of phytohormones in plant material was conducted in conjunction with the University of Adelaide through a newly developed high-throughput assay. A large portion of work during the year for grape and wine research and development went towards the completion of analysis for a collaborative project with the University of Tasmania measuring quality in Australian sparkling wines.

Bioinformatics engagement

The MStractor workflow, a bioinformatics tool for pre-processing raw data from LC-MS and GC-MS non-targeted metabolomics experiments, was published on GitHub, a software development and sharing online platform, making it freely accessible for the wider metabolomics community. The developed workflow has been adopted by other Metabolomics Australia nodes.

A collaboration has been established with IBP-Halle (Germany) and the European Mass Bank Community, with the aim of contributing to and sharing mass spectrometry databases of plant metabolites.

Tracking trends in Australian wine composition and vineyard and winery practices

Background

It is important for the Australian wine sector to track how it is evolving – how common different production practices are and how wine composition is changing. This allows producers to compare their practices with their peers and helps organisations like the AWRI in choosing relevant research and extension activities. This project addresses these goals through a regular practices survey, aggregate analysis of chemical data from AWRI Commercial Services and other targeted activities.

AWRI Vineyard & Winery Practices Survey

The full report from a major survey of Australian vineyard and winery practices was released during the year and is available for download (Figure 30). 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 some technologies have been widely adopted (e.g. cross-flow filtration for wine clarification), while others so far have not been (e.g. sensors to monitor ferment progress).

Figure 30. AWRI Vineyard & Winery Practices Survey (available for download at www.awri.com.au/survey)

SO_2 in wine

As part of its ongoing work to track the compositional trends in Australian wine, the AWRI worked with Wine Australia and data from its export database to review the SO_2 level in more than 3,000 wines from the 2016 and 2017 vintages. The data from this unique source was able to shed significant light on recent trends in the use of this important preservative in different wines. The first, and perhaps most surprising result, was that there was not a significant difference in free sulfur dioxide concentrations between red and white wines, with means of 30.5 and 31.0 mg/L and standard deviations of 9.5 and 10.4 mg/L respectively. This is despite there being significant differences in the average pH for red and white wines, which can have a significant impact on the effectiveness of SO_2 as an inhibitor of microbiological activity. The results may reflect a greater concern about managing oxidation in packaged wine rather than consideration of microbial issues. The distribution of free SO_2 concentrations for red and white wines is shown in Figure 31.

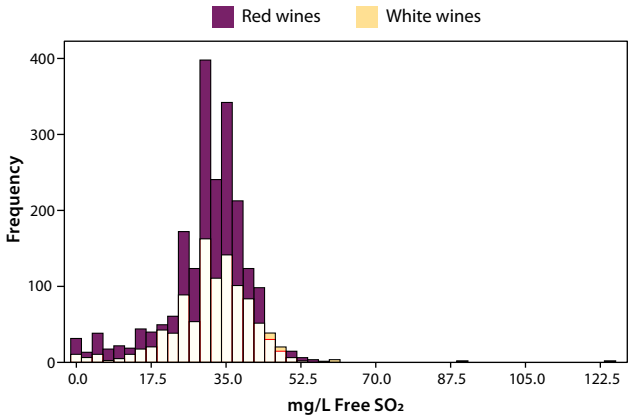

Figure 31. Overlapping distributions of free SO_2 values (mg/L) for 2,119 Australian red wines and 1,048 Australian white wines from the 2016 and 2017 vintages, demonstrating the similar means and distributions (data sourced from Wine Australia's export database)

Of the sample set analysed, 95% were declared as having free SO_2 levels between 20 and 40 mg/L. There was very little variation between the two vintages in the study or among the major grape varieties. Only Pinot Noir and Grenache wines were shown to have significantly lower mean concentrations of free SO_2 (23.7 and 27.3 mg/L respectively). With Pinot Noir this may reflect efforts to avoid colour loss in this variety.

Unsurprisingly, for total SO_2 the mean results were higher for white wines than for reds (113.9 and 83.8 mg/L respectively) reflecting differences in red and white wine production. Levels of total SO_2 are regulated in Australia and most export markets and as such monitoring of the results can be important. All the wines in the study were compliant with the Australian limit of 250 mg/L, with the vast majority of wines significantly below this level (99% of red wines <160 mg/L and 99% of white wines <190 mg/L), easily meeting the requirements of Australia's major export markets. The differences between vintages were small and statistically insignificant (Figure 32). Comparison with the median values for earlier vintages previously published by the AWRI shows a continued downward trend in total SO_2 for white wines. For red wines there appears to be an increase in values; however, it was not clear if this was significant or an artefact of the previous study which relied on results from wines which had been bottled for an unknown period of time. This data will be reviewed on an annual basis.

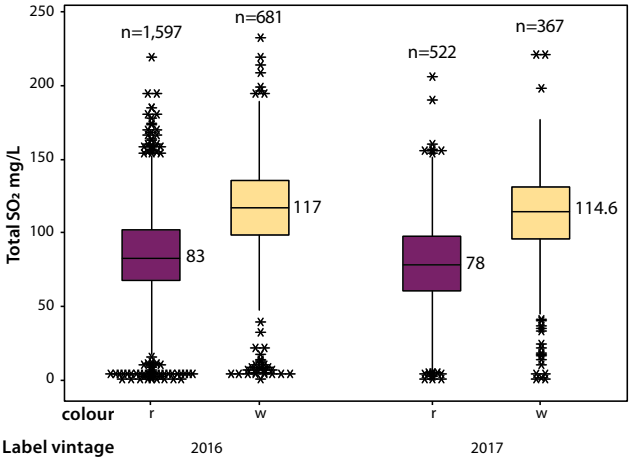

Figure 32. Distribution of total SO_2 (mg/L) levels for 2016 and 2017 vintage red and white wines, outliers excluded. Numbers shown at middle of each box plot represent the median value.

Financial statements – Directors' report

The directors present this report to the members of The Australian Wine Research Institute Limited (the Company) for the year ended 30 June 2019.

Directors

The names of each person who has been a director during the year and to the date of this report are:

	Date of appointment	Cessation date	Board meetings	
			A	B
Ms Louisa E. Rose (Chair)	1 Jan 2011	–	4	4
Mr Tobias J. Bekkers	1 Jan 2014	–	3	4
Ms Wendy Cameron	1 Jan 2018	–	4	4
Dr John S. Harvey	1 Jan 2016	–	4	4
Dr Daniel L. Johnson	1 Dec 2011	–	4	4
Mr Iain M. Jones	1 Jan 2018	–	4	4
Prof. Kiaran D. Kirk	1 Jan 2017	–	4	4
Ms Elizabeth A. Riley	1 Jan 2012	–	4	4
Mr Mark R. Watson	24 Jun 2008	–	4	4
Mr Marcus Y. Woods	19 Oct 2018	–	2	3

A – number of meetings attended
B – number of meetings held during the time the director held office during the year

Directors have been in office since the start of the financial year to the date of this report unless otherwise stated.

Overview of result

For the year ended 30 June 2019 the Company recorded a deficit of $909,556 (2018: deficit of $468,196). This deficit primarily relates to the Company's annual depreciation and amortisation expense recorded in relation to its property, plant, equipment and intangible assets (including its interest in the Wine Innovation Cluster Central building), net of funding received for such items during the period. The directors note that the reported 2019 accounting deficit as well of those in the preceding years are consistent with internal expectations, and reflective of a number of strategic investments made by the Company in order to further support its stakeholders in view of the capacity afforded by the Company's reserves position.

Objectives and strategy

The organisation's long-term objective is to support the Australian grape and wine industry through world-class research, practical solutions and knowledge transfer.

The organisation's short-term objectives are reflected in its 8-Year Research, Development and Extension Plan *The AWRI 2017-2025* which was developed through a wide-ranging industry consultation process and formally commenced on 1 July 2017. This plan details 21 subthemes of activities designed to contribute to the achievement of the Company's mission, grouped within five main themes:

- *Customers, consumers and markets*
- *Extension, adoption and education*
- *Performance, products and processes*
- *Environment, sustainability and natural capital*
- *Foundational data and support services.*

Within these subthemes are 50 projects focusing upon specific outcomes. For each active project a project plan specifies relevant stakeholder needs, deliverables, approaches and methodologies as well as expected outcomes of benefit to the Australian wine industry. The consultation process with industry and other stakeholders remains ongoing, with active projects further developed and refined through Annual Operating Plans.

The Company's strategy for achieving the above objectives is to maximise its available funding to enable the delivery of projects within its Research, Development and Extension Plan, while optimising its internal operations and resources to ensure that such funding is applied as effectively and efficiently as possible. This strategy is implemented through a suite of initiatives, collectively described in the internal document *AWRI Directions – Business and Operational Initiatives 2018-2020*, clustered into four themes:

- World-class people and culture
- Expand the funding base and economic flexibility of the AWRI
- Improve infrastructure, systems and processes
- Build/retain relationships, strategic capabilities, services and partnerships.

The 8-Year Research, Development and Extension Plan *The AWRI 2017-2025*, together with a status summary of the projects within the plan, is available online at awri.com.au.

Principal activities

The Company's principal activities during the year were:

Research activities that strive for scientific excellence and industry relevance;

Development activities that seek to bridge the gap between scientific discovery and value-adding technology or processes;

Extension activities that seek to disseminate research and development outcomes to facilitate rapid uptake by the viticultural and winemaking sectors; and

Commercial services aimed at providing competitive specific and/or tailored solutions for individual entities across all industry sectors which leverage the other key activities of the AWRI.

These activities collectively constitute a mechanism to implement the strategies outlined in *AWRI Directions – Business and Operational Initiatives 2018-2020*, enabling the achievement of the long- and short-term objectives of the organisation as articulated above.

Performance measures

The Company measures its performance through considering the number, quality and impact of the AWRI's scientific publications; its research and development outcomes; the extent to which those outcomes have been adopted by industry practitioners to improve the quality and consistency of wine produced in Australia; and the extent to which that new knowledge has enabled the Australian wine industry to be successful in established and emerging markets. Progress against specific objectives is monitored through the achievement of specific milestones, outputs and performance targets as articulated in *AWRI Directions – Business and Operational Initiatives 2018-2020*, the 8-Year Research, Development and Extension Plan *The AWRI 2018-2025* and individual project plans, combined with measures of use of the AWRI's extension platforms and feedback provided through surveys distributed to service end-users. Financial performance measures include the value of funding and grants received, demand for the organisation's commercial services and contract research capabilities and performance relative to budget. From time to time the Company or parts of its operations are subject to independent review against externally established criteria, with the outcome of such reviews contributing to the Company's assessment of its own performance.

Information on directors

Ms Louisa E. Rose
Chair (non-executive)
Qualifications: BAppSc (Oen), BSc, GAICD
Experience: Head of Winemaking The Yalumba Wine Company and Hill-Smith Family Vineyards, Chair the Alumni Council of the University of Adelaide and Chair of the Council of Barons of Barossa. Previously director of the Barossa Grape & Wine Association, member of Wine Barossa and Co-Chair of the South Australian Wine Industry Council. National wine show judge, 28 years' technical, winemaking, viticultural and commercial experience in the Australian wine industry.
Special Responsibilities: Ms Rose is the Chair of the Personnel committee.

Mr Tobias J. Bekkers
Non-executive director
Qualifications: BAppSc (Ag) (Hons), GradCert (Mgt)
Experience: Principal of Bekkers Consulting and Bekkers Wine. Active as a viticulture and wine business consultant across Australia. Twenty-five years' experience in viticulture and wine business. Formerly General Manager/Senior Viticulturist of Paxton Wines. Board member of McLaren Vale Grape, Wine & Tourism Association. Graduate of the Australian Wine Industry Future Leaders Program and Nuffield Farming Scholar (2017).
Special Responsibilities: Mr Bekkers is a member of the Audit committee.

Ms Wendy Cameron
Non-executive director
Qualifications: BAppSc (Biochem and Microbiol) MSc (Biochem), BAppSc (Wine Sci), GradDip (Ed), GradCert (Bus), MW
Experience: Winemaking consultant, previously Head of Winemaking at Brown Brothers Milawa Vineyards. Over 21 years' experience in the Australian wine sector including winemaking, wine show judging and wine business. Inaugural recipient of the ASVO Winemaker of the Year Award (2012) and Gourmet Traveller Wine Winemaker of the Year finalist (2015). Current PhD candidate at the University of Melbourne.

Dr John S. Harvey
Non-executive director
Qualifications: BSc (Hons), PhD, MBA, FAICD
Experience: Owner of Bathe Wines Pty Ltd. Former Australian Grape and Wine Authority regional mentor for McLaren Vale, past President of the Adelaide Hills Wine Region and previous Member of the South Australian Wine Industry Association Executive. Former Executive Director of the Grape and Wine Research and Development Corporation. Eighteen years' wine industry research, R&D management and commercial experience. Chair of the Can:Do Group, Independent Chair of Studio Nine Architects, Deputy Chair of Rural Business Support, Non-Executive Director of headspace and Revenir Winemaking Pty Ltd, SA Committee Member of the Winston Churchill Memorial Trust (Australia).
Special Responsibilities: Dr Harvey is a member of the Audit committee.

Dr Daniel L. Johnson
Managing Director
Qualifications: BSc (Hons), PhD, MBA, GAICD
Experience: Chair of the Australian Wine Industry Technical Conference, Director of the National Wine Foundation, member of the International Scientific Council of L'Institut des Sciences de la Vigne et du Vin (ISVV) Bordeaux (France), member of the *Australian Journal of Grape and Wine Research* Journal Advisory Committee, member of the *World of Fine Wine* Editorial Board, member of the Wine Innovation Cluster Leadership Group, member of the Waite Strategic Leadership Group, graduate of the Harvard Business School Authentic Leadership Development Program, graduate of the Australian Wine Industry Future Leaders Program, graduate of the INSEAD Blue Ocean Strategy Program, graduate of the IESE Creative Negotiation program, graduate of the Oxford Advanced Management and Leadership Program, Honorary Adjunct Professor at the Macquarie Graduate School of Management, 22 years' experience in research, development and innovation.

Mr Iain M. Jones
Non-executive director
Qualifications: BSc, MSc
Experience: General Manager – Technical Services at Treasury Wine Estates. Over 19 years' experience in the Australian wine sector across laboratory, quality assurance, environmental management, research and development, health and safety, engineering and lean business improvement functions. Member of the Wine Industry Technical Advisory Committee.

Prof. Kiaran D. Kirk
Non-executive director
Qualifications: BSc (Hons), PhD, DPhil
Experience: Dean of the College of Science at the Australian National University (ANU), Chair of Clonakilla Wines. Previously Director of ANU Research School of Biology, Head of ANU Department of Biochemistry and Molecular Biology, and Research Fellow at University of Oxford. More than 23 years' experience in the Australian research sector with a publication record of over 160 research papers in the field of biochemistry.
Special Responsibilities: Prof. Kirk is a member of the Personnel committee.

Ms Elizabeth A. Riley
Non-executive director
Qualifications: BAppSc (Wine Sci)
Experience: Nuffield Farming Scholar, Managing Director and Viticulturist Vitibit Pty Ltd, professional member of the ASVO, associate member of the Hunter Valley Wine and Tourism Association and member of the Wine Innovation Forum, Executive member of the New South Wales Wine Industry Association and Chair of the Research and Development Committee, member of the National Wine Biosecurity Committee. Previously a Viticulturist with Southcorp Wines between 1993 and 1999 in national and NSW-based roles, 26 years' experience in the Australian wine industry. 2017 ASVO Viticulturist of the Year.

Mr Mark R. Watson
Non-executive director
Qualifications: BEc, MBA, CA, RITP, MAICD
Experience: Chief Executive Officer of Radiology SA, having previously held a range of senior management and finance roles including Investment Director of Blue Sky Private Equity, Chief Executive Officer of Water Utilities Australia, Partner Corporate Finance KPMG, Chief Financial Officer Wirra Wirra and Manager, Corporate Strategy and Development FH Faulding & Co Ltd.
Special Responsibilities: Mr Watson is the Chair of the Audit committee.

Mr Marcus Y. Woods
Non-executive director (from 18 October 2018)
Qualifications: BAppSc (Vit), MBA
Experience: Wine Supply Director at Pernod Ricard Winemakers. Over 18 years' viticultural and operational management experience in the Australian sector managing vineyards, wineries and distilleries including with Hardy's, Accolade Wines and the Bickford's Group. Previously a lecturer in Winery Business Management at the University of Adelaide and committee member of the Clare Region Winegrape Growers Association.
Special Responsibilities: Mr Woods is a member of the Personnel committee.

Indemnification of officers and auditors

During the financial year, the Company paid a premium in respect of a contract insuring the directors of the Company (named above), the Company Secretary, all members of the Company's Executive Management Group and members of the Biosafety Committee (a committee including two representatives who are not employees of the Company, charged with oversight of matters pertaining to the development and use of genetically modified organisms and required to be appropriately indemnified by the Office of the Gene Technology Regulator) against a liability incurred in their capacity as a director, secretary, executive or committee member to the extent permitted by the *Corporations Act 2001*. The contract of insurance prohibits disclosure of the nature of the liability and the amount of the premium.

The Company has not otherwise, during or since the end of the financial year, except to the extent permitted by law, indemnified or agreed to indemnify an officer or auditor of the Company or of any related body corporate against a liability incurred as such an officer or auditor.

Members' guarantee

In accordance with the Company's constitution, each member (both during the time he or she is a member and within one year afterwards) is liable to contribute $2 in the event that the Company is wound up. The total amount members would contribute is $20 (2018: $24).

Auditor's independence

The auditor's independence declaration as required under section 60-40 of the *Australian Charities and Not-for-profits Commission (ACNC) Act 2012* is attached and forms part of the directors' report for the financial year ended 30 June 2019.

Dated at Urrbrae on this the 17th day of September 2019.

This report is made in accordance with a resolution of the directors, pursuant to subsection 60.15(2) of the *Australian Charities and Not-for-profits Commission Regulation 2013*.

Louisa E. Rose
Chair

Daniel L. Johnson
Managing Director

Declaration of independence under section 60-40 of the Australian Charities and Not-for-profits Commission Act 2012 by Paul Gosnold to the responsible entities of The Australian Wine Research Institute Limited

As lead auditor of the Australian Wine Research Institute Limited for the year ended 30 June 2019, I declare that, to the best of my knowledge and belief, there have been:

1. No contraventions of the auditor independence requirements of the *Australian Charities and Not-for-profits Commission Act 2012* in relation to the audit; and

2. No contraventions of any applicable code of professional conduct in relation to the audit.

Paul Gosnold
Director
BDO Audit (SA) Pty Ltd
Adelaide, 17 September 2019

The Australian Wine Research Institute Limited

A Company limited by guarantee

Statement of profit or loss and other comprehensive income

For the year ended 30 June 2019

	Note	2019	2018
Revenue from operating activities			
Wine Australia			
Investment agreement project funding		8,632,873	8,649,266
Investment agreement capital funding		67,693	84,731
Other project funding		499,472	658,215
Other capital funding		150,000	90,293
Capital specific grant funding		9,006	–
Other grant funding		611,912	671,574
Commercial services analytical and consulting income		3,350,350	2,979,733
Contract research and other commercial income		1,249,407	1,256,875
Other revenue		160,245	139,603
Total revenue		14,730,959	14,530,290
Other income	2	(2,758)	(13,012)
Expenses from operating activities			
Personnel expenses	3	10,469,699	10,195,529
Analytical and project operating expenses		2,753,764	2,502,750
Infrastructure and general services expenses		1,385,694	1,334,661
Depreciation and amortisation expense	8, 9	1,070,325	1,023,993
Travel expenses		523,588	418,414
Total expenses		16,203,070	15,475,347
Results from operating activities		(1,474,869)	(958,069)
Finance income		565,313	489,873
Profit/(loss) for the period		(909,556)	(468,196)
Other comprehensive income			
Items that will not be reclassified subsequently to profit or loss			
Gain on revaluation of financial assets at fair value through other comprehensive income		315,857	75,354
Total comprehensive income for the period		(593,699)	(392,842)

The notes on pages 64 to 71 are an integral part of these financial statements.

The Australian Wine Research Institute Limited

A Company limited by guarantee

Statement of changes in equity

For the year ended 30 June 2019

	Retained earnings	Co-investment reserve	Strategic IT investment reserve	Financial assets at fair value through OCI reserve	Total equity
Balance at 1 July 2017	14,515,803	864,949	48,292	266,788	15,695,832
Total comprehensive income for the period					
Profit or loss	(468,196)	–	–	–	(468,196)
Other comprehensive income					
Gain on revaluation of financial assets at fair value through other comprehensive income	–	–	–	75,354	75,354
Total other comprehensive income	–	–	–	75,354	75,354
Total comprehensive income for the period	(468,196)	–	–	75,354	(392,842)
Transfers between retained earnings and other reserves					
Transfers to (from) reserves	–	(70,000)	(6,113)	–	(76,113)
Transfers to (from) retained earnings	76,113	–	–	–	76,113
Balance at 30 June 2018	14,123,720	794,949	42,179	342,142	15,302,990
Balance at 1 July 2018	14,123,720	794,949	42,179	342,142	15,302,990
Total comprehensive income for the period					
Profit or loss	(909,556)	–	–	–	(909,556)
Other comprehensive income					
Gain on revaluation of financial assets at fair value through other comprehensive income	–	–	–	315,857	315,857
Total other comprehensive income	–	–	–	315,857	315,857
Total comprehensive income for the period	(909,556)	–	–	315,857	(593,699)
Transfers between retained earnings and other reserves					
Transfers to (from) reserves	–	(80,420)	167,025	66,497	153,102
Transfers to (from) retained earnings	(153,102)	–	–	–	(153,102)
Balance at 30 June 2019	13,061,062	714,529	209,204	724,496	14,709,291

Nature and purpose of reserves

Co-investment reserve

The objective of the co-investment reserve is to provide funds for co-investment in specific funding opportunities, enabling the Company to access certain funding programs subject to the following requirements:

(i) That any co-investment be matched on at least an equal basis from externally sourced funds

(ii) That co-investments create value over the medium to long term for the ultimate benefit of the Australian grape and wine sector

(iii) That co-investments be made only in instances whereby the overall grant funds available to the Australian grape and wine sector are expanded – that is, excluding grant funding programs which already exist for the benefit of that industry.

Strategic IT investment reserve

The objective of the strategic information technology (IT) investment reserve is to ensure that sufficient funds are available for appropriate strategic investment in the Company's IT capabilities, consistent with relevant strategic plans as developed and amended from time to time, approved by the Board of Directors. Resourcing to meet the Company's day-to-day operational IT requirements, as distinct from its strategic IT requirements, is provided by other funding sources as identified within the statement of profit or loss and other comprehensive income.

Financial assets at fair value through other comprehensive income reserve

The reserve is used to recognise increments and decrements in the fair value of financial assets at fair value through other comprehensive income.

The notes on pages 64 to 71 are an integral part of these financial statements.

The Australian Wine Research Institute Limited

A Company limited by guarantee

Statement of financial position

As at 30 June 2019

	Note	2019	2018
Assets			
Cash and cash equivalents	4	2,012,775	2,614,033
Term deposits	5	1,600,000	2,150,000
Trade and other receivables	6	1,280,553	953,469
Inventories	7	94,000	87,522
Prepayments		341,532	350,234
Total current assets		5,328,860	6,155,258
Financial assets at fair value through OCI	5	9,533,476	9,206,837
Property, plant and equipment	8	2,193,352	2,121,069
Intangible assets	9	4,305,310	4,530,166
Total non-current assets		16,032,138	15,858,072
Total assets		21,360,998	22,013,330
Liabilities			
Payables and accruals	10	4,677,456	4,514,366
Project funds not expended	11	41,694	201,906
Provisions	12	1,814,729	1,776,574
Total current liabilities		6,533,879	6,492,846
Provisions	12	117,828	217,494
Total non-current liabilities		117,828	217,494
Total liabilities		6,651,707	6,710,340
Net assets		14,709,291	15,302,990
Equity			
Retained earnings		13,061,062	14,123,720
Co-investment reserve		714,529	794,949
Strategic IT investment reserve		209,204	42,179
Fair value reserve		724,496	342,142
Total equity		14,709,291	15,302,990

The notes on pages 64 to 71 are an integral part of these financial statements.

The Australian Wine Research Institute Limited

A Company limited by guarantee

Statement of cash flows

For the year ended 30 June 2019

	Note	2019	2018
Cash flows from operating activities			
Cash receipts from project grants and other income		13,885,050	15,829,772
Cash paid to suppliers and employees		(14,777,190)	(14,442,760)
Net cash from operating activities		(892,140)	1,387,011
Cash flows from investing activities			
Cash receipts from capital specific funding		217,693	175,024
Interest received		309,697	306,911
Dividends and imputation credits received		240,453	193,162
Proceeds from sale of property, plant and equipment		136	2,800
Acquisition of property, plant, equipment and intangibles		(980,033)	(503,114)
(Acquisition)/proceeds from disposal of term deposits		550,000	(34,708)
Acquisition of financial assets		(1,008)	(200,000)
Payment of transaction costs related to financial investments		(46,056)	(47,755)
Net cash used in investing activities		290,883	(107,679)
Net increase (decrease) in cash and cash equivalents		(601,258)	1,279,332
Cash and cash equivalents at 1 July		2,614,033	1,334,701
Cash and cash equivalents at 30 June	4	2,012,775	2,614,033

The notes on pages 64 to 71 are an integral part of these financial statements.

Notes to and forming part of the financial statements

1. Significant accounting policies

The Australian Wine Research Institute Limited (the "Company") is a company limited by guarantee, domiciled in Australia, incorporated under the *Corporations Act 2001* and registered as a charity under the *Australian Charities and Not-for-profits Commission Act 2012* (ACNC Act). The address of the Company's registered office is the corner of Hartley Grove and Paratoo Road, Urrbrae, South Australia.

The financial statements were authorised for issue by the Board of Directors on the 17th day of September 2019.

Australian Accounting Standards set out accounting policies that the AASB has concluded would result in financial statements containing relevant and reliable information about transactions, events and conditions. Material accounting policies adopted in the preparation of these financial statements are presented below and have been applied consistently to all periods presented in these financial statements, and have been applied consistently by the Company.

Where necessary, comparative information has been reclassified to achieve consistency in disclosure with current financial year amounts and disclosures.

(a) Basis of preparation

(i) Statement of compliance
The financial statements of the Company are Tier 2 general purpose financial statements which have been prepared in accordance with Australian Accounting Standards – Reduced Disclosure Requirements (AASB-RDRs) (including Australian Interpretations) adopted by the Australian Accounting Standards Board (AASB) and the *Australian Charities and Not-for-profits Commission Act 2012* and *Regulation 2013*. The Company is a not-for-profit entity for financial reporting purposes under Australian Accounting Standards.

The Company is exempt from income tax under Section 50-5 of the *Income Tax Assessment Act 1997*, and accordingly no provision for income tax is included in these financial statements.

(ii) Basis of measurement
The financial statements, except for the cash flow information, have been prepared on an accruals basis and are based on historical costs except for some financial assets which are measured at fair value, and do not take into account changing money values.

(iii) Functional and presentation currency
The financial statements are presented in Australian dollars, which is the Company's functional currency.

The Company is of a kind referred to in ASIC Legislative Instrument 2016/191 dated 1 April 2016 and, in accordance with that Legislative Instrument, all financial information presented has been rounded to the nearest dollar unless otherwise stated.

(iv) Use of estimates and judgements
The preparation of financial statements in conformity with Australian Accounting Standards requires management to make judgements, estimates and assumptions that affect the application of accounting policies and the reported amount of assets, liabilities, income and expenses. The estimates and associated assumptions are based on historical experience and various other factors that are believed to be reasonable under the circumstances, the results of which form the basis of making judgements about the carrying value of assets and liabilities that are not readily apparent from other sources.

The estimates and underlying assumptions are reviewed on an ongoing basis. Revisions to accounting estimates are recognised in the period in which the estimates are revised. The Company has identified the allowance for expected credit loss in respect of trade receivables (note 6), the useful lives of property, plant and equipment (note 8), amortisation period of intangible assets including its interest in the WIC building (note 9) and provisions for employee entitlements (note 12) and their respective note 1 accounting policies as areas under which significant judgements, estimates and assumptions are made, and where actual results may differ from those estimates under different assumptions and conditions.

(v) Changes in accounting policies
The company has adopted all of the new or amended Accounting Standards and Interpretations issued by the Australian Accounting Standards Board ('AASB') that are mandatory for the current reporting period. The following Accounting Standards and Interpretations are most relevant to the entity:

AASB 9 Financial Instruments

The company has adopted AASB 9 from 1 July 2018. The standard introduced new classification and measurement models for financial assets. A financial asset shall be measured at amortised cost if it is held within a business model whose objective is to hold assets in order to collect contractual cash flows which arise on specified dates and that are solely principal and interest. A debt investment shall be measured at fair value through other comprehensive income if it is held within a business model whose objective is to both hold assets in order to collect contractual cash flows which arise on specified dates that are solely principal and interest as well as selling the asset on the basis of its fair value. All other financial assets are classified and measured at fair value through profit or loss unless the entity makes

an irrevocable election on initial recognition to present gains and losses on equity instruments (that are not held-for-trading or contingent consideration recognised in a business combination) in other comprehensive income ('OCI'). Despite these requirements, a financial asset may be irrevocably designated as measured at fair value through profit or loss to reduce the effect of, or eliminate, an accounting mismatch. For financial liabilities designated at fair value through profit or loss, the standard requires the portion of the change in fair value that relates to the entity's own credit risk to be presented in OCI (unless it would create an accounting mismatch). New simpler hedge accounting requirements are intended to more closely align the accounting treatment with the risk management activities of the entity.

New impairment requirements use an 'expected credit loss' ('ECL') model to recognise an allowance. Impairment is measured using a 12-month ECL method unless the credit risk on a financial instrument has increased significantly since initial recognition in which case the lifetime ECL method is adopted. For receivables, a simplified approach to measuring expected credit losses using a lifetime expected loss allowance is available.

This standard has been applied from 1 July 2018 resulting in financial statement line items being affected for the current period only. There was no impact on opening retained profits as at 1 July 2018.

(b) Financial assets

Financial assets are initially measured at fair value. Transaction costs are included as part of the initial measurement, except for financial assets at fair value through profit or loss. Such assets are subsequently measured at either amortised cost or fair value depending on their classification. Classification is determined based on both the business model within which such assets are held and the contractual cash flow characteristics of the financial asset unless, an accounting mismatch is being avoided.

Financial assets are derecognised when the rights to receive cash flows have expired or have been transferred and the consolidated entity has transferred substantially all the risks and rewards of ownership. When there is no reasonable expectation of recovering part or all of a financial asset, its carrying value is written off.

Financial assets at fair value through profit or loss
Financial assets not measured at amortised cost or at fair value through other comprehensive income are classified as financial assets at fair value through profit or loss. Typically, such financial assets will be either: (i) held for trading, where they are acquired for the purpose of selling in the short-term with an intention of making a profit, or a derivative; or (ii) designated as such upon initial recognition where permitted. Fair value movements are recognised in profit or loss.

Financial assets at fair value through other comprehensive income
Financial assets at fair value through other comprehensive income include equity investments which the consolidated entity intends to hold for the foreseeable future and has irrevocably elected to classify them as such upon initial recognition.

Impairment
The company recognises a loss allowance for expected credit losses on financial assets which are either measured at amortised cost or fair value through other comprehensive income. The measurement of the loss allowance depends upon the consolidated entity's assessment at the end of each reporting period as to whether the financial instrument's credit risk has increased significantly since initial recognition, based on reasonable and supportable information that is available, without undue cost or effort to obtain.

Where there has not been a significant increase in exposure to credit risk since initial recognition, a 12-month expected credit loss allowance is estimated. This represents a portion of the asset's lifetime expected credit losses that is attributable to a default event that is possible within the next 12 months. Where a financial asset has become credit impaired or where it is determined that credit risk has increased significantly, the loss allowance is based on the asset's lifetime expected credit losses. The amount of expected credit loss recognised is measured on the basis of the probability weighted present value of anticipated cash shortfalls over the life of the instrument discounted at the original effective interest rate.

For financial assets measured at fair value through other comprehensive income, the loss allowance is recognised within other comprehensive income. In all other cases, the loss allowance is recognised in profit or loss.

(c) Property, plant and equipment

(i) Recognition and measurement
Items of property, plant and equipment are measured at cost less accumulated depreciation and accumulated impairment losses. Cost includes expenditure that is directly attributable to the acquisition of the asset, including borrowing costs directly attributable to the acquisition, construction or production of a qualifying asset. Cost also may include transfers from other comprehensive income of any gain or loss on qualifying cash flow hedges of foreign currency purchases of property, plant and equipment. Purchased software that is integral to the functionality of the related equipment is capitalised as part of that equipment.

When parts of an item of property, plant and equipment have different useful lives, they are accounted for as separate items (major components) of property, plant and equipment.

Gains and losses on disposal of an item of property, plant and equipment are determined by comparing the proceeds from disposal with the carrying amount of property, plant and equipment and are recognised net within other income in profit or loss.

(ii) Subsequent costs
The cost of replacing a part of an item of property, plant and equipment is recognised in the carrying amount of the item if it is probable that the future economic benefits embodied within the part will flow to the Company, and its cost can be measured reliably. The carrying amount of the replaced part is derecognised. The costs of the day to day servicing of property, plant and equipment are recognised in profit or loss as incurred.

(iii) Depreciation
Depreciation is calculated over the depreciable amount, which is the cost of an asset, or other amount substituted for cost, less its residual value.

Depreciation is recognised in profit or loss on a straight-line basis over the estimated useful lives of each part of an item of property, plant and equipment, since this most closely reflects the expected pattern of consumption of the future economic benefits embodied in the asset. Leased assets are depreciated over the shorter of the lease term and their useful lives unless it is reasonably certain that the Company will obtain ownership by the end of the lease term.

The estimated useful lives for the current and comparative periods are as follows:

• buildings and improvements	30 years
• plant and machinery	3 – 10 years
• office furniture and IT	3 – 10 years
• laboratory equipment	3 – 10 years

Depreciation methods, useful lives and residual values are reviewed at each financial year-end and adjusted if appropriate.

(d) Intangible assets

Intangible assets that are acquired by the Company and have finite useful lives are measured at cost less accumulated amortisation and accumulated impairment losses.

Amortisation is calculated over the cost of the asset, or another amount substituted for cost, less its residual value. Amortisation is recognised in profit or loss on a straight-line basis over the estimated useful lives of intangible assets from the date that they are available for use, since this most closely reflects the expected pattern of consumption of the future economic benefits embodied in the asset. Amortisation methods, useful lives and residual values are reviewed at each financial year-end and adjusted if appropriate.

(e) Leased assets

The Company has entered into leases of motor vehicles and office equipment as disclosed in note 13. Management has determined that all of the risks and rewards of ownership of these motor vehicles and equipment remain with the lessor and has therefore classified the leases as operating leases, and the leased assets are not recognised in the Company's statement of financial position. The Company's commitments at reporting date in regards to operating leases are disclosed in note 13.

(f) Inventories

Inventories are measured at the lower of cost and net realisable value. The cost of inventories includes expenditure incurred in acquiring the inventories and other costs incurred in bringing them to their existing location and condition. Net realisable value is the estimated selling price in the ordinary course of business, less selling expenses.

(g) Impairment

The carrying amounts of the Company's non-financial assets are reviewed at each reporting date to determine whether there is any indication of impairment. If any such indication exists, then the asset's recoverable amount is estimated.

The recoverable amount of an asset is the greater of its value in use and its fair value less costs to sell. Value in use is determined as the current replacement cost of an asset.

An impairment loss is recognised if the carrying amount of an asset exceeds its estimated recoverable amount. Impairment losses are recognised in profit or loss. Impairment losses recognised in prior periods are assessed at each reporting date for any indications that the loss has decreased or no longer exists. An impairment loss is reversed if there has been a change in the estimates used to determine the recoverable amount. An impairment loss is reversed only to the extent that would have been determined, net of depreciation or amortisation, if no impairment loss had been recognised.

(h) Employee benefits

(i) Defined contribution plans

A defined contribution plan is a post-employment benefit plan under which an entity pays fixed contributions into a separate entity and will have no legal or constructive obligation to pay further amounts. Obligations for contributions to defined contribution plans are recognised as an employee benefit expense in profit or loss in the periods during which services are rendered by employees.

(ii) Other long-term employee benefits

The Company's net obligation in respect of long-term employee benefits is the amount of future benefit that employees have earned in return for their service in the current and prior periods plus related on-costs. The liability is measured such that it is not materially different from the estimate determined by discounting using market yields at the reporting date on corporate bonds with terms to maturity and currencies that match, as closely as possible, the estimated future cash outflows.

(iii) Termination benefits

Termination benefits are recognised as an expense when the Company is demonstrably committed, without realistic probability of withdrawal, to a formal detailed plan to either terminate employment before the normal retirement date, or to provide termination benefits as a result of an offer made to encourage voluntary redundancy. Termination benefits for voluntary redundancies are recognised as an expense if the Company has made an offer of voluntary redundancy, it is probable that the offer will be accepted, and the number of acceptances can be estimated reliably. If benefits are payable more than 12 months after the reporting period, then they are discounted to their present value.

(iv) Short-term benefits

Short-term employee benefit obligations are measured on an undiscounted basis and are expensed as the related service is provided.

A liability is recognised for the amount expected to be paid under short-term bonus plans if the Company has a present legal or constructive obligation to pay this amount as a result of past service provided by the employee and the obligation can be measured reliably. Such liabilities represent the best estimate of the amounts required to settle the obligation at the end of the reporting period.

(i) Revenue

(i) Goods sold

Revenue from the sale of goods in the course of ordinary activities is measured at the fair value of the consideration received or receivable, net of any applicable discounts or rebates. Revenue is recognised when persuasive evidence exists, usually in the form of an executed sales agreement, that the significant risks and rewards of ownership have been transferred to the buyer, recovery of the consideration is probable, the associated costs and possible return of goods can be estimated reliably, there is no continuing management involvement with the goods, and the amount of revenue can be measured reliably.

(ii) Services

Revenue from services rendered is recognised in profit or loss in proportion to the stage of completion of the transaction at the reporting date. The stage of completion is assessed by reference to an estimation of the work performed.

(iii) Grants

The company receives a number of grants in the course of its operations. Once the company has been notified of the successful outcome of a grant application, the terms and conditions of each grant are reviewed to determine whether the funds relate to a reciprocal grant (i.e. payment for services rendered), in which case it is accounted for under AASB 118 *Revenue*, or a non-reciprocal grant, in which case it is accounted for under AASB 1004 *Contributions*.

(j) Finance income

Finance income comprises interest income and dividends. Interest income is recognised as it accrues in profit or loss using the effective interest rate method. Dividend income is recognised in profit or loss on the date on which the Company's right to receive payment is established.

Finance costs comprise interest expense on borrowings and impairment losses recognised on financial assets other than trade receivables. Borrowing costs that are not directly attributable to the acquisition, construction or production of a qualifying asset are recognised in profit or loss using the effective interest rate method.

(k) Lease payments

Payments made under operating leases are recognised in profit or loss on a straight-line basis over the term of the lease.

Determining whether an arrangement contains a lease

At inception of an arrangement, the Company determines whether such an arrangement is or contains a lease. A specific asset is the subject of a lease if fulfilment of the arrangement is dependent upon the use of that specified asset. An arrangement conveys the right to use the asset if the arrangement conveys to the Company the right to control the use of the underlying asset. At inception or upon reassessment of the arrangement, the Company separates payments and other consideration required by such an arrangement into those for the lease and those for other elements on the basis of their relative fair values.

(l) Goods and services tax

Revenue, expenses and assets are recognised net of the amount of goods and services tax (GST), except where the amount of GST incurred is not recoverable from the taxation authority. In these circumstances, the GST is recognised as part of the cost of acquisition of the asset or as part of the expense.

Receivables and payables are stated with the amount of GST included. The net amount of GST recoverable from, or payable to, the ATO is included as a current asset or current liability in the statement of financial position.

Cash flows are included in the statement of cash flows on a gross basis. The GST components of the cash flows arising from investing and financing activities which are recoverable from, or payable to, the ATO are classified as operating cash flows.

(m) Trade and other receivables

Trade receivables are initially recognised at fair value and subsequently measured at amortised cost using the effective interest method, less any allowance for expected credit losses. Trade receivables are generally due for settlement within 30 days. The company has applied the simplified approach to measuring expected credit losses, which uses a lifetime expected loss allowance. To measure the expected credit losses, trade receivables have been grouped based on days overdue. Other receivables are recognised at amortised cost, less any allowance for expected credit losses.

2. Other income

	2019	2018
Net gain/(loss) on sale of property, plant and equipment	(2,758)	(13,012)
	(2,758)	(13,012)

3. Personnel expenses

	2019	2018
Wages and salaries	9,274,996	8,883,313
Other associated personnel expenses	324,675	479,488
Contributions to defined contribution plans	870,028	832,728
	10,469,699	10,195,529

4. Cash and cash equivalents

	2019	2018
Cash on hand	377	107
Bank deposits at-call	2,012,398	2,613,926
Cash and cash equivalents in the statement of cash flows	2,012,775	2,614,033

5. Other investments

	2019	2018
Current		
Term deposits	1,600,000	2,150,000
Non-current		
Financial assets at fair value through OCI, comprising listed investments at fair value in:		
Interest rate securities	5,892,842	5,807,952
Equity securities	3,640,634	3,398,885
	9,533,476	9,206,837

Term deposits have interest rates between 2.75 and 2.80 percent (2018: between 2.50 and 2.80 percent) and mature within 6 months of balance date (2018: within 9 months of balance date).

All equity securities and interest rate securities are quoted on the Australian Securities Exchange. Interest rate securities include corporate bonds, subordinated notes and convertible and reset preference securities.

6. Trade and other receivables

	2019	2018
Trade receivables due from those other than related parties	803,059	586,359
Trade receivables due from related parties	10,045	127
Other receivables	467,449	366,983
	1,280,553	953,469

Trade receivables are shown net of expected credit losses amounting to $23,312 (2018: $7,498) at reporting date. This allowance account is used to record expected credit losses until the Company is satisfied that no recovery of the amount owing is possible; at that point the amounts are considered irrecoverable and are written off against the financial asset directly.

The movement in the allowance for expected credit losses in respect of trade receivables during the year was as follows:

	2019	2018
Balance at 1 July	7,498	4,431
Payments received in relation to previous expected credit loss balances	–	–
Expected credit loss for the year	15,815	6,761
Written off during the year	–	(3,694)
Balance at 30 June	23,313	7,498

7. Inventories

	2019	2018
Course materials on hand – wine	94,000	87,522
	94,000	87,522

8. Property, plant and equipment

	Plant and machinery	Office furniture and IT	Laboratory equipment	Capital WIP	Total
Cost					
Balance at 1 July 2018	554,872	1,141,865	9,862,839	3,247	11,562,823
Additions	81,964	68,730	662,038	–	812,732
Transfers	–	–	3,247	(3,247)	–
Disposals	(1,800)	(23,423)	(138,865)	–	(164,088)
Balance at 30 June 2019	635,036	1,187,172	10,389,259	–	12,211,467
Depreciation and impairment losses					
Balance at 1 July 2018	381,431	852,783	8,207,540	–	9,441,754
Depreciation charge for the year	53,705	139,087	544,763	–	737,555
Transfers	–	–	–	–	–
Disposals	(1,800)	(20,638)	(138,756)	–	(161,194)
Balance at 30 June 2019	433,336	971,232	8,613,547	–	10,018,115
Carrying amounts					
at 1 July 2018	173,441	289,082	1,655,299	3,247	2,121,069
at 30 June 2019	201,700	215,940	1,775,712	–	2,193,352

9. Intangible assets

	Interest in WIC building	Computer software	Intangible assets under development	Total
Cost				
Balance at 1 July 2018	6,100,140	622,641	–	6,722,781
Additions	–	70,452	37,462	107,914
Transfers	–	–	–	–
Disposals	–	(6,851)	–	(6,851)
Balance at 30 June 2019	6,100,140	686,242	37,462	6,823,844
Amortisation and impairment losses				
Balance at 1 July 2018	1,950,865	241,750	–	2,192,615
Amortisation charge for the year	203,338	129,432	–	332,770
Disposals	–	(6,851)	–	(6,851)
Balance at 30 June 2019	2,154,203	364,331	–	2,518,534
Carrying amounts				
at 1 July 2018	4,149,275	380,891	–	4,530,166
at 30 June 2019	3,945,937	321,911	37,462	4,305,310

Interest in WIC building

The Company has a 50-year nominal occupancy right to approximately 53% of the space in the Wine Innovation Cluster (WIC) Central building owned by the University of Adelaide. The other occupants are currently the University of Adelaide and Fight Food Waste Cooperative Research Centre. The term of occupancy is reviewable after 30 years based on the remaining economic life of the building. The value assigned to the AWRI's interest in the building is net of amounts contributed by Wine Australia (WA). The building cost is being amortised over a period of 30 years from the date of practical completion (26 November 2008).

Computer software

Computer software assets are recognised as the attributable software licence and development costs paid to third parties, and do not include employee costs or an attribution of relevant overheads, as only an immaterial component of software development and testing processes are performed in-house. These software assets are amortised over periods of between three and five years, based upon their estimated useful lives and expected technical obsolescence.

10. Payables and accruals

	2019	2018
Current		
Trade payables due to those other than related parties	283,175	298,395
Trade payables due to related parties	397	38
Income received in advance	1,046,206	1,163,011
PAYG and GST	463,141	439,438
Non-trade payables and accrued expenses	2,884,537	2,613,484
	4,677,456	4,514,366

11. Project funds not expended

Any unexpended WA funding is reimbursable to WA, except where WA agrees that amounts can be retained by the AWRI for purposes approved by WA, at which point such amounts are considered to be committed towards that purpose. Project underspends recorded in the year ended 30 June 2019 may be reduced or eliminated by overspends recorded within those projects in prior years – where applicable, the unexpended funds detailed below have been reduced by such amounts.

There were no unexpended investment agreement funds for the current year (2018: $97,260, relating only to funding to be provided to project collaborators in future periods). There were no unexpended funds from other WA contracts for the current year (2018: $104,646).

During the year WA approved the retention by the Company of $97,260 unspent prior years' funds to be provided to project collaborators in future periods (2018: nil) and $104,646 for other project delivery purposes (2018: $137,254). During the year no unspent prior years' funds relating to WA projects were returned to WA (2018: $121,155).

	2019	2018
WA current year's investment agreement funding unexpended	–	97,260
WA current year's other contract funding unexpended	–	104,646
WA prior years' funding unexpended	41,694	–
	41,694	201,906

12. Provisions

	2019	2018
Current		
Employee entitlements	1,814,729	1,776,574
Non-current		
Employee entitlements	117,828	217,494
Number of employees (full-time equivalents)	104.2	96.9

13. Operating leases

Leases as lessee

Non-cancellable operating lease rentals are payable as follows:

	2019	2018
Within one year	3,432	12,841
One year or later and no later than five years	9,438	12,870
Later than five years	–	–
	12,870	25,711

The Company did not enter into any new operating lease agreements during the year.

During the year ended 30 June 2019 an amount of $12,841 was recognised as an expense in respect of operating leases (2018: $13,697).

Leases as lessor

The Company leases out part of its interest in the WIC building (refer note 9) to the Australian Wine Industry Technical Conference Incorporated. Associated lease payments are included within the transactions with related parties disclosed within note 15. The future minimum lease payments under non-cancellable leases are receivable as follows:

	2019	2018
Within one year	8,000	8,000
One year or later and no later than five years	1,333	9,333
Later than five years	–	–
	9,333	17,333

During the year ended 30 June 2019 an amount of $8,464 was recognised as rental income (2018: $8,259).

14. Capital commitments

	2019	2018
Property, plant and equipment		
Contracted but not provided for and payable		
Within one year	80,560	162,830
One year or later and no later than five years	–	–
Later than five years	–	–
	80,560	162,830

15. Related parties

Key management personnel compensation

Key management personnel comprises the directors of the Company and other persons having authority and responsibility for planning, directing and controlling the activities of the Company. Key management personnel compensation comprised:

	2019	2018
Total remuneration	1,888,087	1,865,846

During the year non-executive directors became entitled to compensation totalling $88,500 (2018: $83,000). A number of directors voluntarily elected not to receive $54,750 of this entitlement (2018: $51,000), instead redirecting such amounts to support otherwise unfunded activities of the Company relating to individual and group professional development for AWRI staff, undertaken both domestically and internationally, as well as providing support to visiting scientists.

Key management personnel and director transactions

A number of key management personnel, or their related parties, hold positions in other entities that result in them having control or significant influence over the financial or operating policies of these entities.

A number of these entities transacted with the Company in the reporting period. The terms and conditions of the transactions with key management personnel and their related parties were no more favourable than those available, or which might reasonably be expected to be available, on similar transactions to non-key management personnel related entities on an arm's length basis.

Related parties arising through relationships with key management personnel:

Arrivo Wine
Bathe Wines Pty Ltd
Oenologie Requin Pty Ltd (trading as Bekkers Wine)
Revenir Winemaking Pty Ltd
Vitibit Pty Ltd

Other related party transactions

During the year the Company provided administrative services and leased office premises to a jointly controlled entity, The Australian Wine Industry Technical Conference Incorporated.

Other related parties:
The Australian Wine Industry Technical Conference Incorporated

Transactions with related parties

	Transactions value for the year ended 30 June		Balance outstanding as at 30 June	
	2019	2018	2019	2018
Services received from related parties	3,453	2,787	397	38
Services provided to related parties	134,336	94,428	10,045	127

16. Contingencies

In the opinion of the Directors, there were no material or significant contingent liabilities at 30 June 2019 (2018: none).

17. Subsequent events

There has not arisen in the interval between the end of the financial year and the date of this report any other item, transaction or event of a material and unusual nature likely to significantly affect the operations of the Company, the results of those operations, or the state of affairs of the Company, in subsequent financial years.

18. Limited liability

In accordance with the Company's constitution, each member (both during the time he or she is a member and within one year afterwards) is liable to contribute $2 in the event that the Company is wound up. The total amount members would contribute is $20 (2018: $24).

Responsible persons' declaration

The directors of The Australian Wine Research Institute Limited (the Company) declare that, in the directors' opinion:

(a) the financial statements, comprising the statement of profit or loss and other comprehensive income, statement of financial position, statement of cash flows, statement of changes in equity, and accompanying notes, are in accordance with the *Australian Charities and Not-for-profits Commission Act 2012* and:

(i) comply with Australian Accounting Standards – Reduced Disclosure Requirements and the *Australian Charities and Not-for-profits Commission Regulation 2013*; and

(ii) give a true and fair view of the entity's financial position as at 30 June 2019 and of its performance for the year ended on that date; and

(b) there are reasonable grounds to believe that the Company will be able to pay all of its debts, as and when they become due and payable.

Signed in accordance with subsection 60.15(2) of the *Australian Charities and Not-for-profits Commission Regulation 2013*.

Louisa E. Rose
Chair

Daniel L. Johnson
Managing Director

Dated at Urrbrae on this the 17th day of September 2019.

Independent auditor's report to the members of The Australian Wine Research Institute Limited

Report on the Audit of the Financial Report

Opinion

We have audited the financial report of the Australian Wine Research Institute Limited (the registered entity), which comprises the statement of financial position as at 30 June 2019, the statement of profit or loss and other comprehensive income, the statement of changes in equity and the statement of cash flows for the year then ended, and notes to the financial report, including a summary of significant accounting policies, and the responsible entities' declaration.

In our opinion the accompanying financial report of the Australian Wine Research Institute Limited, is in accordance with Division 60 of the *Australian Charities and Not-for-profits Commission Act 2012*, including:

(i) Giving a true and fair view of the registered entity's financial position as at 30 June 2019 and of its financial performance for the year then ended; and

(ii) Complying with Australian Accounting Standards – Reduced Disclosure Requirements and Division 60 of the *Australian Charities and Not-for-profits Commission Regulation 2013*.

Basis for opinion

We conducted our audit in accordance with Australian Auditing Standards. Our responsibilities under those standards are further described in the *Auditor's responsibilities for the audit of the Financial Report* section of our report. We are independent of the registered entity in accordance with the auditor independence requirements of the *Australian Charities and Not-for-profits Commission Act 2012* (ACNC Act) and the ethical requirements of the Accounting Professional and Ethical Standards Board's APES 110 *Code of Ethics for Professional Accountants* (the Code) that are relevant to our audit of the financial report in Australia. We have also fulfilled our other ethical responsibilities in accordance with the Code.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Other information

Those charged with governance are responsible for the other information. The other information obtained at the date of this auditor's report is the Directors' Report included in the Australian Wine Research Institute Limited's annual report.

Our opinion on the financial report does not cover the other information and accordingly we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial report, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial report or our knowledge obtained in the audit or otherwise appears to be materially misstated.

If, based on the work we have performed on the other information obtained prior to the date of this auditor's report, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Responsibilities of responsible entities for the Financial Report

The responsible entities of the registered entity are responsible for the preparation and fair presentation of the financial report in accordance with Australian Accounting Standards – Reduced Disclosure Requirements and the ACNC Act, and for such internal control as the responsible entities determine is necessary to enable the preparation of the financial report that is free from material misstatement, whether due to fraud or error.

In preparing the financial report, responsible entities are responsible for assessing the registered entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the responsible entities either intends to liquidate the registered entity or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the registered entity's financial reporting process.

Auditor's responsibilities for the audit of the Financial Report

Our objectives are to obtain reasonable assurance about whether the financial report as a whole is free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with the Australian Auditing Standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of this financial report.

A further description of our responsibilities for the audit of the financial report is located at the Auditing and Assurance Standards Board website (http://www.auasb.gov.au/Home.aspx) at: http://www.auasb.gov.au/auditors_responsibilities/ar4.pdf

This description forms part of our auditor's report.

BDO Audit (SA) Pty Ltd

Paul Gosnold
Director

Adelaide, 25 September 2019

Memorial funds

Consisting of (and collectively the "Trusts"):

The John Fornachon Memorial Library Endowment Fund
The Thomas Walter Hardy Memorial Trust Fund
The H. R. Haselgrove Memorial Trust Fund
The Stephen Hickinbotham Memorial Research Trust

Statement by directors of the trustee company

The Australian Wine Research Institute Limited (the "Trustee") acts as unrewarded trustee for the above listed Trusts. As detailed in note 2 to these financial statements, the Trusts are not reporting entities because, in the Trustee's opinion, it is unlikely that users exist who are unable to command the preparation of reports tailored so as to satisfy, specifically, all of their information needs. This is a special purpose financial report that has been prepared to meet the reporting obligations of the Trustee.

In the opinion of the directors of The Australian Wine Research Institute Limited (the Trustee):

(a) (i) the statements of profit or loss and other comprehensive income give a true and fair view of each Trust's profit or loss for the year ended 30 June 2019; and

(ii) the statements of financial position give a true and fair view of each Trust's state of affairs as at 30 June 2019.

(b) at the date of this statement, there are reasonable grounds to believe that the Trusts will be able to pay their debts as and when they fall due.

This statement is made in accordance with a resolution of the directors of the trustee company and is signed for and on behalf of the directors by:

Louisa E. Rose
Chair
Dated at Urrbrae on this the 17th day of September 2019.

Notes to the financial statements

1. Nature and purpose of the Trusts

(a) The John Fornachon Memorial Library Endowment Fund was established on 30 September 1970, to provide for the establishment and maintenance of the Fornachon Memorial Library, for the promotion of study and general knowledge of the wine industry. The Fund was established by way of public appeal on a memorial to the late John Charles Macleod Fornachon, the Director of Research of The Australian Wine Research Institute Limited from 1955 to 1968.

(b) The Thomas Walter Hardy Memorial Trust Fund was established on 29 June 1993 to assist in the communication of information within the wine industry and associated activities, allied to the wine industry on behalf of the Trust. The Trust was established in memory of the late Thomas Walter Hardy.

(c) The H.R. Haselgrove Memorial Trust Fund was established on 12 December 1979 to provide for the promotion and encouragement of wine research by, or under the direction of, The Australian Wine Research Institute Limited as a memorial to the late Harry Ronald Haselgrove.

(d) The Stephen Hickinbotham Memorial Research Trust was established on 7 October 1986 to provide financial assistance and support in the pursuit of scientific research and associated activities, allied to the wine industry. The Trust was established in memory of the late Stephen John Hickinbotham. The Australian Wine Research Institute Limited assumed responsibility for the Trust on 25 May 1992.

2. Statement of accounting policies

In the opinion of the Trustee, the Trusts are of a type identified in Statement of Accounting Concepts 1 as non-reporting entities. Accordingly, the financial statements constitute 'special purpose financial reports' which have been prepared solely to meet the reporting obligations of the Trustee, and the limited information needs of the Trusts' members.

The financial statements have been prepared in accordance with accounting standards, except as stated below, and other mandatory professional reporting requirements.

The following accounting standards have not been adopted because, in the opinion of the Trustee, the cost of compliance outweighs the benefit of the resultant information:

- AASB 7 Financial Instruments: Disclosures
- AASB 107 Statement of Cash Flows
- AASB 124 Related Party Disclosures
- AASB 132 Financial Instruments: Presentation

The financial statements have been prepared on an accrual basis.

Accounting policies have been consistently applied, with the only significant policy being in relation to investments.

Investments interest rate securities and exchange traded funds, all of which are quoted on the Australian Securities Exchange and recorded at fair value through other comprehensive income. Investment income is brought to account as earned, with accrued earnings at balance date being included in the statement of financial position as receivables.

STATEMENTS OF PROFIT OR LOSS AND OTHER COMPREHENSIVE INCOME	The John Fornachon Memorial Library Endowment Fund		The Thomas Walter Hardy Memorial Trust Fund		The H. R. Haselgrove Memorial Trust Fund		The Stephen Hickinbotham Memorial Research Trust	
For the year ended 30 June 2019	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**
Income								
Investments	5,230	984	3,492	660	3,379	639	4,053	766
Donations and other income	–	–	–	–	–	–	–	–
Total income	5,230	984	3,492	660	3,379	639	4,053	766
Expenses								
Investment management expenses	508	–	355	–	349	–	396	–
Contribution towards Library Management System	1,565	3,909	–	–	–	–	–	–
Sponsorship	–	–	–	–	–	–	–	–
Total expenses	2,073	3,909	355	–	349	–	396	–
Profit/(loss) from ordinary activities	3,157	(2,925)	3,137	660	3,030	639	3,657	766
Other comprehensive income								
Items that will not be reclassified subsequently to profit or loss:								
Gain on revaluation of financial assets at fair value through other comprehensive income	6,815	–	4,592	–	4,412	–	5,272	–
Total comprehensive income for the period	9,972	(2,925)	7,729	660	7,442	639	8,929	766
STATEMENTS OF FINANCIAL POSITION								
As at 30 June 2019	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**
Assets								
Cash at bank	4,787	–	3,056	–	3,194	–	3,840	–
Investments	–	133,876	–	89,794	–	87,011	–	104,207
Receivables	1,432	77	957	52	925	50	1,109	60
Total current assets	6,219	133,953	4,014	89,846	4,119	87,061	4,949	104,267
Investments	139,271	–	93,561	–	90,385	–	108,247	–
Total non-current assets	139,271	–	93,561	–	90,385	–	108,247	–
Total assets	145,490	133,953	97,575	89,846	94,504	87,061	113,196	104,267
Liabilities								
Committed funding contribution	5,474	3,909	–	–	–	–	–	–
Total current liabilities	5,474	3,909	–	–	–	–	–	–
Net assets	140,016	130,044	97,575	89,846	94,504	87,061	113,196	104,267
Trust funds								
Settled sum	12,785	12,785	50	50	20,000	20,000	50	50
Founders donation	–	–	25,000	25,000	–	–	–	–
	12,785	12,785	25,050	25,050	20,000	20,000	50	50
Accumulated surplus								
Opening balance	117,259	120,184	64,796	64,136	67,061	66,422	104,217	103,451
Profit/(loss) for the year	3,157	(2,925)	3,137	660	3,030	639	3,657	766
Transfers to (from) accumulated surplus	(187)	–	(128)	–	(125)	–	(153)	–
Closing balance	120,228	117,259	67,805	64,796	69,967	67,061	107,720	104,217
Financial assets at fair value through other comprehensive income reserve								
Opening balance	–	–	–	–	–	–	–	–
Gain on revaluation of financial assets at fair value through other comprehensive income	6,815	–	4,592	–	4,412	–	5,272	–
Transfers to (from) reserve	187	–	128	–	125	–	153	–
Closing balance	7,002	–	4,720	–	4,537	–	5,426	–
Total trust funds	140,016	130,044	97,575	89,846	94,504	87,061	113,196	104,267

APPENDIX 1

External presentations

Staff	Title of presentation	Presented to and where	Date
E.N. Wilkes	Process-driven analysis, a better way to run testing in wine production	Gallo winemakers' briefing, Modesto, California, USA	2 Jul 2018
G.D. Cowey	Acid matters. Getting the balance right	American Society for Enology and Viticulture – Eastern Section 43rd Annual Conference, King of Prussia, Pennsylvania, USA	11 Jul 2018
M.L. Longbottom	Current Australian exotic pest incursions	Heathcote phylloxera forum, Heathcote, Vic	17 Jul 2018
P.W. Godden	Evaluation of winemaking treatments in Australian Shiraz	Shiraz winemaking trial tasting, McLaren Vale, SA	19 Jul 2018
G.D. Cowey	Wine flavours, taints and faults, wine texture and a wine show judging exercise	Pernod Ricard Winemakers sensory evaluation workshop, Barossa Valley, SA	20 Jul 2018
N. Scrimgeour	Can we get closure? Shining new light on the role of closures in wine faults	Interwinery Analysis Group seminar, Barossa, SA	
W.P. Pearson	Benchmarking Australian Shiraz terroir	Australia Decanted, Lake Tahoe, California, USA	23 Jul 2018
M.L. Longbottom	Current Australian exotic pest incursions	ASVO Innovation Seminar, Mildura, Vic	25 Jul 2018
P.R. Petrie	Using agrochemical data to monitor trends and identify future issues		
M. Essling	Challenges to agrochemical availability		
P.W. Godden	Winemaking trials with sooty mould		26 Jul 2018
R.G. Dambergs	Hyperspectral image analysis of *Botrytis* in grapes		
M.G. Holdstock	Evaluation of winemaking treatments in Australian Shiraz tasting	Shiraz winemaking trial tasting, Gippsland, Vic	
M.P. Day	Oxygen is not all bad – oxygen additions during ferment	Winery Engineers' Association Conference, Nuriootpa, SA	
S. Nordestgaard	Membrane contactors and oxygen measurement equipment		
M.G. Holdstock	Evaluation of winemaking treatments in Australian Shiraz	Shiraz winemaking trial tasting, Geelong, Vic	27 Jul 2018
M.P. Krstic	AWRI Annual Report 2017/2018	NSW Wine Industry Association meeting, Orange, NSW	6 Aug 2018
	AWRI update on viticulture and sustainability	NSW Innovation Forum, Orange, NSW	7 Aug 2018
J.M. McRae	Knowledge makes new – enriching wine experience through research	South Australian Tourism Industry Council's Tourism innovation and entrepreneurship workshop, Adelaide, SA	
C.A. Simos	Evaluation of winemaking treatments in Australian Shiraz	Shiraz winemaking trial tasting, Treasury Wine Estates, Barossa Valley, SA	8 Aug 2018
D. Espinase Nandorfy	Wine on my mind – neuroscience of wine flavour	Neuroscience at night, Adelaide, SA	17 Aug 2018
S. Dillon	Brewing the world's oldest beer	Healthy Australian Agribusiness 2020+, Adelaide, SA	23 Aug 2018
P.R. Petrie	Climate change – adaptation techniques for the wine industry	Romeo Bragato Conference, Wellington, NZ	30 Aug 2018
M.P. Krstic	Working with climate change – adaptation techniques		
J.L. Hixson	The flavour of bottle-aged Riesling – predicting and controlling future chemistry	AWRI webinar	

Staff	Title of presentation	Presented to and where	Date
M.L. Longbottom	Biosecurity – current and future risks	AWRI webinar	6 Sep 2018
M. Essling	Agrochemicals update	Murray Valley Winegrowers pre-season checklist workshop, Swan Hill, Vic	11 Sep 2018
A.J. Hoare	The benefits of soil, petiole and sap testing		
	Managing nitrogen for optimal yield and quality		
M. Essling	Agrochemicals update	Murray Valley Winegrowers pre-season checklist workshop, Mildura, Vic	12 Sep 2018
A.J. Hoare	The benefits of soil, petiole and sap testing		
	Managing nitrogen for optimal yield and quality		
A.R. Borneman	Synthetic biology, Yeast 2.0 and their potential to impact the winemaker's art	Bioflavour 2018 conference, Frankfurt, Germany	20 Sep 2018
K.A. Bindon	How to maximise the phenolic potential of grapes through innovative winemaking	AWRI roadshow seminar, Langhorne Creek, SA	
J.M. McRae	Hot news in heat stability!		
S.A. Schmidt	The beneficial style and performance effects of oxygen addition during fermentation		
G.D. Cowey	Masterclass and palate calibration of wine taints and faults	Sommeliers Australia, Melbourne, Vic	24 Sep 2018
M.J. Herderich	BAG projects and new AWRI research	BAG Meeting, Hochschule Geisenheim University, Geisenheim, Germany	
R. Gawel	The effect of dissolved CO_2 on the taste and texture of still white and red wines	Crush 2018 – the grape and wine science symposium, Adelaide	25 Sep 2018
W.P. Pearson	Sensory profiles of regional Australian Shiraz: characterisation by a new rapid sensory method		
M. Parker	Increasing wine flavour by adding glycosides from grape marc		
M.P. Day	New isotopic markers for the provenance authentication of Australian wines		
S.R. Barter	α-Guaiene is a key precursor of the impact aroma compound rotundone in Shiraz grapes		
R.G. Dambergs	Hyperspectral imaging of *Botrytis* in grapes		26 Sep 2018
K.A. Bindon	Zoning in on Shiraz grape quality		
C.A. Varela	Discovering the indigenous yeast microflora associated with Australian Aboriginal fermentations		
T.J. Abbott	Battery storage: the answer to all your problems or an expensive toy?		
K.C. Hirlam	Does the right closure provide closure for your wine?		
J.M. McRae	Perfecting heat application to predict and prevent protein haze in white wines		
P.J. Costello	Malolactic starter culture performance in difficult wine conditions – can it be improved?		
J.R. Bellon	Wine can increase fitness? Just ask yeast!		
J.L. Hixson	A mechanistic approach to Riesling accelerated ageing		
A.R.Borneman	Wild wine: metagenomic analysis of microbial communities during wine fermentation	ASVO Oenology Seminar, Adelaide, SA	27 Sep 2018
G.D. Cowey	Managing problematic malolactic fermentation		
M.P. Day	Modern winemaking: or how I learned to stop worrying and love oxygen		

Staff	Title of presentation	Presented to and where	Date
S.A. Schmidt	Spoilt for choice – towards a comprehensive understanding of yeast traits to facilitate strain selection	ASVO Oenology Seminar, Adelaide, SA	27 Sep 2018
J.R. Bellon	A new breed of wine yeast	Department of Genome Sciences, University of Washington, Seattle, USA	28 Sep 2018
M.J. Herderich	Chemistry of wine flavour	Food, Flavour & Fragrances Seminar, Astar, Singapore	3 Oct 2018
T.E. Siebert	Why does this wine smell like apricots?	AWRI webinar	4 Oct 2018
E.N. Wilkes	Maximum residue limits, an expensive habit	FIVS meeting, Honolulu, Hawaii, USA	9 Oct 2018
A.J. Hoare	Canopy management to optimise quality	Addressing regional challenges workshop, Mudgee, NSW	
M. Essling	Yield regulation – cost-benefit and the impact on quality		
	Your regional position – helpdesk, climate and wine composition trends, fuel and power use in your region, through Entwine Australia sustainability benchmarking		
M.G. Holdstock	Colour and tannin		
	pH and TA – getting it right		
	Optimising MLF and preventing spoilage		
	Oxygen use in winemaking		
	Bulk wine transport		
A.J. Hoare	Canopy management to optimise quality	Addressing regional challenges workshop, Orange, NSW	10 Oct 2018
M. Essling	Stretching water further		
	Your regional position – helpdesk, climate and wine composition trends, fuel and power use in your region, through Entwine Australia sustainability benchmarking		
M.G. Holdstock	Update on manganese restrictions, water additions, nutrition, proctase use		
	Colour and tannin		
	Optimising MLF and preventing spoilage		
	Carboxymethylcellulose tartrate inhibitor		
	Avoiding stuck fermentations		
E.N. Wilkes	A closer look at some analytes tested in APEC economies that do not protect consumers, nor indicate quality or authenticity	APEC Wine Regulatory Forum, Hawaii, USA	
	2018 APEC WRF ring test result review		11 Oct 2018
	Proposal: results from ISO170325 laboratories be accepted in destination market		
A.J. Hoare	Yield regulation – cost-benefit and the impact on quality	Addressing regional challenges workshop, Canberra District, NSW	
M. Essling	Stretching water further		
	Your regional position – helpdesk, climate and wine composition trends, fuel and power use in your region, through Entwine Australia sustainability benchmarking		
M.G. Holdstock	Optimising MLF and preventing spoilage		
	New *Brettanomyces* treatment options		
	Sulfides and copper treatment		
	Colour and tannin		
	pH and TA – getting it right		

Staff	Title of presentation	Presented to and where	Date
C.A. Simos	AWRI helpdesk statistics – viticulture	First Families of Wines visit to the AWRI, Adelaide, SA	11 Oct 2018
M.L. Longbottom	'Dog book' updates and new tools		
	National sustainability program		
	Biosecurity		
N. Habili	Virus testing		
M.P. Krstic	Soil health		
K.A. Bindon	Grape objective measures		
P.R. Petrie	Digital solutions at the weighbridge		
M.J. Herderich	Rotundone and links to vineyard terroir		
P.R. Petrie	Terroir in Barossa Shiraz		
A.R. Borneman	Insights in grapevine genomics		
P.J. Costello	Malolactic fermentation – research round-up at the AWRI	Wine Tasmania Winemakers' Symposium, Rosevears, Tasmania	16 Oct 2018
I.L. Francis	What are the key Chardonnay volatile compounds (and how can we improve on the Tassie standard)?		
G.D. Cowey	Masterclass and palate calibration of wine taints and faults	Sommeliers Australia, Sydney, NSW	
M.Z. Bekker	Post-bottling formation of stinky sulfur aromas in wines and remediation solutions	Oxygen and sulfur workshop at Pernod Ricard Winemakers, Barossa, SA	18 Oct 2018
M.P. Day	How I learned to stop worrying and love oxygen		
D.L. Johnson	A tale of shipwrecks, beer and yeast	Adelaide Club Professionals' Luncheon, Adelaide, SA	23 Oct 2018
M.L. Longbottom	Yield estimation	Winemaking Tasmania – annual client day conference, Hobart, Tas	26 Oct 2018
A.J. Hoare	Mid-row management options for pest and disease control	Integrated pest management workshop, Geelong, Vic	
M. Essling	Regional trends in chemical use and the importance of spray coverage		
A.J. Hoare	Mid-row management options for pest and disease control	Integrated pest management workshop, Rutherglen, Vic	30 Oct 2018
M. Essling	Regional trends in chemical use and the importance of spray coverage		
A.J. Hoare	Mid-row management options for pest and disease control	Integrated pest management workshop, Avoca, Vic	31 Oct 2018
M. Essling	Regional trends in chemical use and the importance of spray coverage		
S.A. Schmidt	Spoiled for choice in winemaking: supporting humanity's oldest profession in the genomics era	Waite in the Spotlight, Adelaide, SA	1 Nov 2018
A.J. Hoare	Mid-row management options for pest and disease control	Integrated pest management workshop, Yarra Valley, Vic	
M. Essling	Regional trends in chemical use and the importance of spray coverage		
A.J. Hoare	Mid-row management options for pest and disease control	Integrated pest management workshop, Mornington Peninsula, Vic	2 Nov 2018
M. Essling	Regional trends in chemical use and the importance of spray coverage		
C.A. Simos	Copper – the good, the bad and the ugly	AWRI roadshow seminar, Mt Barker, WA	6 Nov 2018
	Hot news in heat stability!		
A.J. Hoare	What are the strategies to better manage the risk of *Botrytis* bunch rot?		

Staff	Title of presentation	Presented to and where	Date
I.L. Francis	Complexity, texture and flavour ... or green, hard and herbal? Incorporation of stems and leaves in cool climate Shiraz fermentation	AWRI roadshow seminar, Mt Barker, WA	6 Nov 2018
	Struck match and tropical fruit: the role of varietal thiols in Australian Chardonnay		
M.J. Roach	Population sequencing reveals clonal diversity and ancestral inbreeding in the grapevine cultivar Chardonnay	Australasian Genomic Technologies Association conference, Adelaide, SA	7 Nov 2018
C.A. Simos	*Brettanomyces* – causes and management strategies	AWRI roadshow seminar, Pemberton, WA	
A.J. Hoare	What are the strategies to better manage the risk of *Botrytis* bunch rot?		
	Soil health – what is it and how can we manage it?		
	What are the positives and pitfalls of grazing sheep in your vineyard?		
I.L. Francis	Keep calm and keep face: understanding Chinese wine consumers		
K.A. Bindon	Objective measures of grape quality	Concha y Toro Centre for Research and Innovation, Talca, Chile	8 Nov 2018
K.A. DeGaris	Salinity – practical information for growers	AWRI webinar	
C.A. Simos	Copper – the good, the bad and the ugly	AWRI roadshow seminar, Margaret River, WA	
A.J. Hoare	What are the strategies to better manage the risk of *Botrytis* bunch rot?		
	What are the positives and pitfalls of grazing sheep in your vineyard?		
I.L. Francis	Struck match and tropical fruit: the role of varietal thiols in Australian Chardonnay		
	The voice of the consumers: why should we listen?		
K.A. Bindon	Objective measures of grape quality	UC Davis Chile, Santiago, Chile	9 Nov 2018
C.A. Simos	Hot news in heat stability!	AWRI roadshow seminar, Swan Valley, WA	
A.J. Hoare	Organic vs conventional practices compared – what's stopping you from going organic?		
	Soil health – what is it and how can we manage it?		
I.L. Francis	Struck match and tropical fruit: the role of varietal thiols in Australian Chardonnay		
	Keep calm and keep face: understanding Chinese wine consumers		
C.A. Simos	Shiraz winemaking trial tasting	Shiraz winemaking trial tasting, Pernod Ricard Winemakers, Barossa Valley, SA	13 Nov 2018
	Introduction to the course	Institute of Masters of Wine one-day wine assessment course, Adelaide, SA	15 Nov 2018
W.P. Pearson	Wine flavours, faults and taints		
C.A. Simos	Introduction to the Advanced Wine Assessment Course	Advanced Wine Assessment Course (AWAC 47), Adelaide, SA	19 Nov 2018
W.P. Pearson	Flavours, taints, faults and thresholds		
M. Parker	Increasing wine flavour by adding glycosides from grape marc	AWRI webinar	20 Nov 2018
R. Gawel	Measuring judge performance	Advanced Wine Assessment Course (AWAC 47), Adelaide, SA	22 Nov 2018
W.P. Pearson	Benchmarking Australian Shiraz: a sensory exercise	Institute of Masters of Wine students and MWs, National Wine Centre, Adelaide SA	

Staff	Title of presentation	Presented to and where	Date
C.A. Varela	Chemical-genetic interactions in a wine yeast deletion library	7th International Yeast 2.0 and Synthetic Genomes Conference, Sydney, NSW	26 Nov 2018
D.L. Johnson	Raising the synthetic bar		27 Nov 2018
C.A. Simos	Can I improve MLF performance and reliability?	AWRI roadshow seminar, Gippsland, Vic	
M.L. Longbottom	Best practice approaches to assessing harvest time – grape maturity and pest and disease levels		
	How to improve fruit set in cool climates		
R. Gawel	What makes a red wine green?		
A.R. Borneman	Constructing a synthetic yeast pan-genome neochromosome	7th International Yeast 2.0 and Synthetic Genomes Conference, Sydney, NSW	28 Nov 2018
C.S. Stockley	Controlling the highs and lows of wine – how low should we go?	New Tastes of Wine Symposium – Sustainable Consumption, University of Newcastle, Newcastle, NSW	29 Nov 2018
M.L. Longbottom	Entwine Australia	Orange Region Vignerons' Association sustainability workshop, Orange, NSW	15 Jan 2019
	Benchmarking performance with Entwine Australia		
C.A. Simos	Flavours, faults and taints	Institute of Masters of Wine Winter program, Rust, Austria	
P.W. Godden	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Institute of Masters of Wine, London, UK	18 Jan 2019
		Cabernet Sauvignon winemaking trial tasting, Clare Valley, SA	21 Jan 2019
C.A. Simos	Making attractive, distinctive and complex wines – an insight into the AWRI's flavour research	Australia Trade Tasting, London, UK	22 Jan 2019
P.W. Godden	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Barossa Valley, SA	
		Cabernet Sauvignon winemaking trial tasting, Langhorne Creek, SA	23 Jan 2019
		Cabernet Sauvignon winemaking trial tasting, McLaren Vale, SA	24 Jan 2019
D.L. Johnson	AWRI Annual Report 2017/2018	Queensland Wine Industry Association Board meeting, Mount Cotton, Qld	
C.A. Simos	Winemaking overview with a focus on climate change and the AWRI's flavour research	Institute of Masters of Wine, Deidesheim, Germany	25 Jan 2019
M.G. Holdstock	Causes and management of slow and stuck fermentations	AWRI roadshow seminar, Yarra Valley, Vic	30 Jan 2019
A.J. Hoare	How to get the most out of your planting material		
P.R. Petrie	What can I do to protect my vineyard from climate change?		
R. Gawel	White wine texture: the interactive effects of phenolics, polysaccharides, acidity and alcohol		
M.G. Holdstock	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Yarra Valley, Vic	
G.D. Cowey		Cabernet Sauvignon winemaking trial tasting, Mount Barker, WA	
G.D. Cowey	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Margaret River, WA	31 Jan 2019
A.J. Hoare	How to improve fruit set in cool climates	AWRI roadshow seminar, Mornington Peninsula, Vic	
	How to get the most out of your planting material		
R. Gawel	White wine texture: the interactive effects of phenolics, polysaccharides, acidity and alcohol		

Staff	Title of presentation	Presented to and where	Date
C.A. Simos	*Brettanomyces* – causes and management strategies	AWRI roadshow seminar, Mornington Peninsula, Vic	31 Jan 2019
A.J. Hoare	How to improve fruit set in cool climates	AWRI roadshow seminar, Geelong, Vic	1 Feb 2019
P.R. Petrie	What can I do to protect my vineyard from climate change?		
R. Gawel	Struck match and tropical fruit: the role of varietal thiols in Australian Chardonnay		
	White wine texture: the interactive effects of phenolics, polysaccharides, acidity and alcohol		
M.G. Holdstock	Causes and management of slow and stuck fermentations		
C.A. Simos	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Canberra District, NSW	6 Feb 2019
P.W. Godden		Cabernet Sauvignon winemaking trial tasting, Great Western, Vic	
M.G. Holdstock		Cabernet Sauvignon winemaking trial tasting, Rutherglen, Vic	
		Cabernet Sauvignon winemaking trial tasting, Orange, NSW	7 Feb 2019
P.W. Godden		Cabernet Sauvignon winemaking trial tasting, Avoca, Vic	
M.G. Holdstock		Cabernet Sauvignon winemaking trial tasting, Mudgee, NSW	8 Feb 2019
P.W. Godden		Cabernet Sauvignon winemaking trial tasting, Bendigo, Vic	
D.L. Johnson	Licensing unpatented yeast strains	AUTM 2019 Annual Meeting, Austin, USA	11 Feb 2019
C.A. Simos, M.P. Krstic	Smoke taint Q&A	Smoke taint Q&A session, Cambridge, Tas	13 Feb 2019
		Smoke taint Q&A session, Hobart, Tas	
M.G. Holdstock	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Coonawarra, SA	
R.G. Dambergs	Digital solutions for grape quality measures at the weighbridge	EvokeAg Symposium, Melbourne, Vic	19 Feb 2019
M.L. Longbottom	Best practice approaches to assessing harvest time – grape maturity and pest and disease levels	AWRI roadshow seminar, Stanthorpe, Qld	21 Feb 2019
S.A. Schmidt	Copper – the good, the bad and the ugly		
	The beneficial style and performance effects of oxygen addition during fermentation		
C.A. Simos	Causes and management of slow and stuck fermentations		
	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Stanthorpe, Qld	
W. P. Pearson	Shiraz terroir project – Pivot© profile tasting	China trade key opinion leaders group, Adelaide, SA	25 Feb 2019
M. Essling	Organic vs conventional practices compared – what's stopping you from going organic?	AWRI roadshow seminar, Launceston, Tas	27 Feb 2019
	What are the strategies to better manage the risk of *Botrytis* bunch rot?		
A.J. Hoare	Chemical resistance management for vineyards		
	How to get the most out of your planting material		

Staff	Title of presentation	Presented to and where	Date
M. Essling	Organic vs conventional practices compared – what's stopping you from going organic?	AWRI roadshow seminar, Hobart, Tas	28 Feb 2019
	What are the strategies to better manage the risk of *Botrytis* bunch rot?		
A.J. Hoare	Chemical resistance management for vineyards		
	How to get the most out of your planting material		
P.W. Godden	The origins of the black pepper compound rotundone in grapes	OIV MSc in Wine Management students, Adelaide, SA	
A.R. Borneman	Wild fermentation and regionality: metagenomic analysis of microbial communities during wine fermentation		
D.L. Johnson	AWRI Annual Report 2017/2018	Wines of Western Australia Board Meeting, Perth, WA	22 Mar 2019
M.J. Herderich	Managing *Brettanomyces* in wine	OIV Microbiology Expert Group Meeting, Paris, France	29 Mar 2019
W. P. Pearson	Shiraz terroir project – Pivot© profile tasting	China vintage trip group, Adelaide, SA	1 Apr 2019
L. Nicolotti	MStractor: a workflow for non-targeted data processing of LC-MS and GC-MS data files	metaRbolomics meeting, Martin-Luther-Universität, Halle-Wittenberg, Germany	2 Apr 2019
M.L. Longbottom	Sustainability in the grape and wine sector	South Australian Wine Industry Association Environment Committee, Magill, SA	9 April 2019
A.J. Hoare, N. Habili	Monitoring for grapevine viruses in established vineyards	AWRI webinar	11 Apr 2019
S.A. Schmidt	A tale of two alleles? If only it were that simple: genetic contributions to volatile thiol production by wine yeast	Yeast and Fermented Beverage Flavour Joint Symposium, Sonoma County, California, USA	24 Apr 2019
W.P. Pearson	Shiraz terroir project – Pivot© profile tasting	Asia trade group visit, Adelaide, SA	29 Apr 2019
C.A. Simos	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Mildura, Vic	6 May 2019
S. Nordestgaard	New technologies for dissolved gas management		
C.A. Simos	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Griffith, NSW	8 May 2019
A.J. Hoare	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Griffith, NSW	
	Understanding powdery mildew and discovering strategies to help control the disease		
S. Nordestgaard	Trends in Australian grapegrowing practices		
M.L. Longbottom	Sustainable Winegrowing Australia	McLaren Vale Grape, Wine & Tourism Association information night, Willunga, SA	
M.G. Holdstock	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	'Australia Wine Discovered' education program, Adelaide, SA	
A.J. Hoare	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Mildura, Vic	9 May 2019
S. Nordestgaard	Trends in Australian grapegrowing practices		
A.J. Hoare	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Loxton, SA	10 May 2019
S. Nordestgaard	Trends in Australian grapegrowing practices		
	Innovations in on-harvester destemming and sorting		
C.A. Simos	Evaluation of winemaking treatments in Australian Shiraz	Cabernet Sauvignon winemaking trial tasting, Loxton, SA	
S. Nordestgaard	New technologies for dissolved gas management		
K.A. Bindon	Tailoring Chardonnay grape and wine quality in a warm climate	8th symposium of the OENOVITI International Network and 12th General Assembly of the Network, Agricultural University of Athens, Athens, Greece	13 May 2019

Staff	Title of presentation	Presented to and where	Date
C.A. Simos	Introduction to the Advanced Wine Assessment Course	Advanced Wine Assessment Course (AWAC 48), Adelaide, SA	13 May 2019
W.P. Pearson	Flavours, taints, faults and thresholds		
R. Gawel	Measuring judge performance		16 May 2019
J. Gledhill	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, University of Adelaide, Adelaide, SA	
C.A. Simos	Introduction to the Advanced Wine Assessment Course	Advanced Wine Assessment Course (AWAC 49), Adelaide, SA	20 May 2019
W.P. Pearson	Flavours, taints, faults and thresholds		
M. Parker	Factors contributing to variation in retronasal odour perception from glycoconjugates	12th Wartburg Symposium on Flavour Chemistry and Biology, Eisenach, Germany	21 May 2019
C.A. Varela	Discovering the microbiome: potential applications for novel non-conventional wine yeasts	Enoforum 2019, Vicenza, Italy	22 May 2019
R. Gawel	Measuring judge performance	Advanced Wine Assessment Course (AWAC 49), Adelaide, SA	23 May 2019
	Polyphenols in food and wine	Science as a Human Endeavour (SHE) Program (Yr 12 SACE chemistry), Saint Ignatius College, SA	28 May 2019
P.W. Godden	Using science to understand the sensory properties of wine	Bioplatforms Australia meeting, Hahndorf, SA	
A.J. Hoare	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Mudgee, NSW	29 May 2019
M.G. Holdstock	Causes and management of slow and stuck fermentations		
R. Gawel	Polyphenols in food and wine	Science as a Human Endeavour (SHE) Program (Yr 12 SACE chemistry), Adelaide High School, SA.	30 May 2019
A.J. Hoare	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Hunter Valley, NSW	
M.G. Holdstock	Evaluation of winemaking treatments in Australian Cabernet Sauvignon	Cabernet Sauvignon winemaking trial tasting, Hunter Valley, NSW	
M.L. Longbottom	Sustainable Winegrowing Australia	NSW Wine meeting, Sydney, NSW	2 Jun 2019
K.A. Bindon	Using maceration techniques to tailor red wine styles	E. & J. Gallo Winery Statewide Short Course, Lodi, California, USA	5 Jun 2019
M.L. Longbottom	Sustainable Winegrowing Australia	Regional briefing, Adelaide, SA	7 Jun 2019
		Yalumba meeting, Angaston, SA	11 Jun 2019
M.G. Holdstock	Masterclass and palate calibration of wine taints and faults	Sommeliers Australia, Melbourne, Vic	18 Jun 2019
G.D. Cowey	Wine taints and faults, oak flavours, thresholds, tannin and mouth-feel perception	Tasting for Cooperages 1912, Adelaide, SA	19 Jun 2019
M.P. Krstic	The AWRI, Chardonnay genomics project and smoke taint insights	Edmund Mach Foundation, San Michele all'Adige, Italy	
M.L. Longbottom	Sustainable Winegrowing Australia	Treasury Wine Estates meeting, Nuriootpa, SA	20 Jun 2019
K.A. Bindon	The secret life of wine macromolecules	70th ASEV National Conference, Napa Valley, California, USA	21 Jun 2019
T.E. Siebert	Identification of compounds responsible for 'apricot' and 'stone fruit' aroma and flavour in wine	BAG Alliance General Assembly, Bordeaux, France	24 Jun 2019
M.J. Herderich	AWRI update: sustainable grapegrowing and winemaking, climate change and extreme weather events, upcoming replantings in Australia		
M.L Longbottom	Sustainable Winegrowing Australia	Adelaide Hills wine region information night, Woodside, SA	25 Jun 2019
K.A. Bindon	The secret life of wine macromolecules	Midwest Grape and Wine Industry Institute, Iowa State University, Ames, Iowa, USA and remotely to Dept. Food Sciences, Cornell University, Ithaca, New York, USA	26 Jun 2019

Staff	Title of presentation	Presented to and where	Date
Y. Hayasaka	A tool for catching mice in wine: development and application of a method for the detection of mousy off-flavour compounds in wine	11th International Symposium of Enology of Bordeaux/11th Edition of In Vino Analytica Scientia, Bordeaux, France	26 Jun 2019
M.Z. Bekker	Are dicysteinyl polysulfanes responsible for post-bottling release of hydrogen sulfide?		
Y.D. Grebneva	HPLC-MS Analysis of carotenoids as potential precursors for 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN) in Riesling grapes		27 Jun 2019
T.E. Siebert	Can varietal 'apricot' aroma of Viognier wine be controlled with clonal selection and harvest timing?		28 Jun 2019

APPENDIX 2

Events organised by AWRI staff

Staff	Title of event	Held	Date
K.J. Dunne, M.L. Longbottom	Heathcote phylloxera forum	Heathcote, Vic	17 Jul 2018
P.W. Godden, V.F. Phillips	Shiraz winemaking trial tasting	McLaren Vale, SA	19 Jul 2018
G.D. Cowey	Pernod Ricard Winemakers sensory evaluation workshop	Barossa Valley, SA	20 Jul 2018
M.G. Holdstock, V.F. Phillips	Shiraz winemaking trial tasting	Gippsland, Vic	26 Jul 2018
		Geelong, Vic	27 Jul 2018
C.A. Simos, V.F. Phillips	Shiraz winemaking trial tasting, Treasury Wine Estates	Barossa Valley, SA	8 Aug 2018
J.M. McRae, J.R. Bellon, S.R. Barter, T.E. Siebert, L.E. Bey, M.P. Day, C.S. Stockley, C.E. Bartel, S. Dillon, D. Thornton-Wakefield, D. Espinase Nandorfy, E.O. Bilogrevic, J.K. O'Mahony	Grape expectations! The future of wine	Adelaide, SA	14 Aug 2018
			15 Aug 2018
C.A. Simos, V.F. Phillips, P.W. Godden, K.A. Bindon, J.M. McRae, S.A. Schmidt	AWRI roadshow seminar	Langhorne Creek, SA	20 Sep 2018
G.D. Cowey, F. Gapper	Masterclass and palate calibration of wine taints and faults for Sommeliers Australia	Melbourne, Vic	24 Sep 2018
M.G. Holdstock, A.J. Hoare, M. Essling, V.F. Phillips	Addressing regional challenges workshop	Mudgee, NSW	9 Oct 2018
		Orange, NSW	10 Oct 2018
		Canberra District, NSW	11 Oct 2018
C.A. Simos, M.L. Longbottom, N. Habili, M.P. Krstic, K.A. Bindon, P.R. Petrie, M.J. Herderich, A.R. Borneman	First Families of Wines visit to the AWRI, Adelaide, SA	Adelaide, SA	
G.D. Cowey, F. Gapper	Masterclass and palate calibration of wine taints and faults for Sommeliers Australia	Sydney, NSW	16 Oct 2018
M. Essling, A.J. Hoare	Integrated pest management workshop	Geelong, Vic	26 Oct 2018
		Rutherglen, Vic	30 Oct 2018
		Avoca, Vic	31 Oct 2018

Staff	Title of event	Held	Date
M. Essling, A.J. Hoare	Integrated pest management workshop	Yarra Valley, Vic	1 Nov 2018
		Mornington Peninsula, Vic	2 Nov 2018
C.A. Simos, A.J. Hoare, I.L. Francis, V.F. Phillips	AWRI roadshow seminar	Mount Barker, WA	6 Nov 2018
		Pemberton, WA	7 Nov 2018
		Margaret River, WA	8 Nov 2018
		Swan Valley, WA	9 Nov 2018
M. Essling	Spray application workshop	Stanthorpe, Qld	13 Nov 2018
C.A. Simos, V.F. Phillips	Shiraz winemaking trial tasting, Pernod Ricard Winemakers	Barossa Valley, SA	
M. Essling	Spray application workshop	Orange, NSW	15 Nov 2018
C.A. Simos, F. Gapper, F. Blefari, G.D. Cowey, M.F. Calabrese, M.G. Holdstock, E.-M. Panagis	Institute of Masters of Wine one-day wine assessment course	Adelaide, SA	
M. Essling	Spray application workshop	Canberra District, NSW	16 Nov 2018
C.A. Simos, F. Blefari, W.P. Pearson, F. Gapper, E.-M. Panagis, V.F. Phillips, G.D. Cowey, M.G. Holdstock	Advanced Wine Assessment Course (AWAC 47)	Adelaide, SA	19-22 Nov 2018
C.A. Simos, M.L. Longbottom, R. Gawel, V.F. Phillips	AWRI roadshow seminar	Gippsland, Vic	27 Nov 2018
P.W. Godden, F. Gapper	Cabernet Sauvignon winemaking trial tasting	Clare Valley, SA	21 Jan 2019
		Barossa Valley, SA	22 Jan 2019
C.A. Simos	Aroma wall	London, UK	
P.W. Godden, F. Gapper	Cabernet Sauvignon winemaking trial tasting	Langhorne Creek, SA	23 Jan 2019
		McLaren Vale, SA	24 Jan 2019
C.A. Simos, V.F. Phillips, M.G. Holdstock, A.J. Hoare, P.R. Petrie, R. Gawel	AWRI roadshow seminar	Yarra Valley, Vic	30 Jan 2019
C.A. Simos, F. Gapper, G.D. Cowey	Cabernet Sauvignon winemaking trial tasting	Mount Barker, WA	
C.A. Simos, V.F. Phillips		Yarra Valley, Vic	
G.D. Cowey, F. Gapper		Margaret River, WA	31 Jan 2019
C.A. Simos, V.F. Phillips, M.L. Longbottom, R. Gawel	AWRI roadshow seminar	Mornington Peninsula, Vic	
C.A. Simos, V.F. Phillips, M.G. Holdstock, A.J. Hoare, P.R. Petrie, R. Gawel		Geelong, Vic	1 Feb 2019
M.G. Holdstock, V.F. Phillips, F. Gapper	Cabernet Sauvignon winemaking trial tasting	Rutherglen, Vic	6 Feb 2019
P.W. Godden, V.F. Phillips, F. Gapper		Great Western, Vic	
C.A. Simos, V.F. Phillips, F. Gapper		Canberra, ACT	
		Orange, NSW	7 Feb 2019
P.W. Godden, V.F. Phillips, F. Gapper		Avoca, Vic	
C.A. Simos, V.F. Phillips, F. Gapper		Mudgee, NSW	8 Feb 2019
P.W. Godden, V.F. Phillips, F. Gapper		Bendigo, Vic	
C.A. Simos, M.P. Krstic	Smoke taint Q&A session	Cambridge, Tas	13 Feb 2019
		Hobart, Tas	
C.A. Simos, F. Gapper	Cabernet Sauvignon winemaking trial tasting	Coonawarra, SA	

Staff	Title of event	Held	Date
C.A. Simos, V.F. Phillips, M.L. Longbottom, S.A. Schmidt	AWRI roadshow seminar	Stanthorpe, Qld	21 Feb 2019
C.A. Simos, V.F. Phillips	Cabernet Sauvignon winemaking trial tasting		
C.A. Simos, E.-M. Panagis, W.P. Pearson	China trade key opinion leaders visit	Adelaide, SA	25 Feb 2019
M. Essling, A.J. Hoare, V.F. Phillips	AWRI roadshow seminar	Launceston, Tas	27 Feb 2019
		Hobart, Tas	28 Feb 2019
C.A. Simos, E.-M. Panagis, W.P. Pearson	China vintage trip group visit	Adelaide, SA	1 Apr 2019
C.A. Simos, W.P. Pearson	Asia trade group visit		29 Apr 2019
C.A. Simos, V.F. Phillips, S. Nordestgaard	Cabernet Sauvignon winemaking trial tasting	Mildura, Vic	6 May 2019
C.A. Simos, V.F. Phillips		Griffith, NSW	8 May 2019
C.A. Simos, V.F. Phillips, A.J. Hoare, S. Nordestgaard	AWRI roadshow seminar		
		Mildura, Vic	9 May 2019
		Loxton, SA	10 May 2019
C.A. Simos, V.F. Phillips, S. Nordestgaard	Cabernet Sauvignon winemaking trial tasting		
C.A. Simos, F. Blefari, W.P. Pearson, E.-M. Panagis, V.F. Phillips, J. Scudds, G.D. Cowey, M.G. Holdstock	Advanced Wine Assessment Course (AWAC 48)	Adelaide, SA	13-16 May 2019
J. Gledhill, V.F. Phillips	Cabernet Sauvignon winemaking trial tasting, University of Adelaide		16 May 2019
C.A. Simos, F. Blefari, W.P. Pearson, E.-M. Panagis, V.F. Phillips, J. Scudds, G.D. Cowey, M.G. Holdstock	Advanced Wine Assessment Course (AWAC 49)		20-23 May 2019
M.G. Holdstock, A.J. Hoare, V.F. Phillips	AWRI roadshow seminar	Mudgee, NSW	29 May 2019
N.D.R. Lloyd	Metabolomics Australia analytical meeting	Adelaide, SA	29-30 May 2019
M.G. Holdstock, A.J. Hoare, V.F. Phillips	AWRI roadshow seminar	Hunter Valley, NSW	30 May 2019
M.G. Holdstock, V.F. Phillips	Cabernet Sauvignon winemaking trial tasting		
A.H. Forgan, C.A. Varela	2019 South Australian Biosafety Committee Network meeting	Adelaide, SA	13 Jun 2019
M.G. Holdstock, E.-M. Panagis	Flavours, faults and aroma tasting for Sommeliers Australia	Melbourne, Vic	18 Jun 2019
G.D. Cowey, E.-M. Panagis	Tasting for Cooperages 1912	Adelaide, SA	19 Jun 2019

APPENDIX 3

Posters

Staff	Title of poster	Presented at	Date
J.R. Bellon, C.M. Ford[1], A.R. Borneman, S.A. Schmidt	Wine can increase fitness. Just ask yeast!	Yeast Genetics Meeting, Stanford University, USA	22-26 Aug 2018
Y.D. Grebneva, J.R. Bellon, D. Rauhut[2], M. Stoll[2], M.J. Herderich, J.L. Hixson	Manipulating Riesling wine ageing potential during fermentation	Bioflavour 2018, Frankfurt, Germany	18-21 Sep 2018
S. Nordestgaard	Australian wine: a statistical history	Vinitech-Sifel, Bordeaux, France	20-22 Nov 2018
	Equipment evolution: destemming		
	Equipment evolution: pressing (batch)		
	Equipment evolution: pressing (continuous)		
J.R. Bellon, S. Nordestgaard	Introducing new breeds of wine yeast		
T.E. Siebert, D. Espinase Nandorfy, S.R. Barter, I.L. Francis	Mimicking 'apricot' aroma of Viognier wine and assessing its control through grape berry composition	12th Wartburg Symposium on Flavor Chemistry & Biology	21-24 May 2019
A.C. Kulcsar, A. Faucon[3], P.A. Smith[4], M.Z. Bekker	Evaluating the effectiveness of five commonly used strategies for the remediation of 'reductive' aromas	11th International Symposium of Enology of Bordeaux/11th Edition of In Vino Analytica Scientia, Bordeaux, France	25-28 Jun 2019

Affiliations of non-AWRI authors: [1]University of Adelaide, [2]Hochschule Geisenheim University, Geisenheim, Germany, [3]Montpellier SupAgro, Montpellier, France, [4]Wine Australia

APPENDIX 4

Teaching responsibilities (lectures) of AWRI staff

Institution	Subject number	Subject name	No of lectures	Staff member
University of Adelaide	2502WT	Sensory studies II	1	G.D. Cowey
	7520WT	Advances in wine science	1	C.A. Simos
	7047WT	Winemaking at vintage	1	M.P. Day
	CHEM 2530	Environmental and analytical chemistry II	2	J.A. Culbert
	3007WT/7010WT	Stabilisation and clarification	1	J.M. McRae
			3	A.D. Coulter
			1	M.Z. Bekker
	3046WT/7046WT	Fermentation technology	2	I.L. Francis
	3500WT/7560WT	Grape and wine industry practice policy and communication III B Viticulture/Experiences and perspectives in the wine industry	1	
			1	S.A. Schmidt
	3500WT	Biotechnology in the food and wine industries III	1	
University of Melbourne	UNIB10009	Food for a healthy planet	1	C.S. Stockley
Melbourne Polytechnic	AGR3WM2	Winemaking 2	1	M.G. Holdstock
University of South Australia	Short course	Premium food and wine marketing	3	I.L. Francis
			1	C.A. Simos

APPENDIX 5

Student supervision responsibilities of AWRI staff

Student	Supervisors	Source of funds
PhD		
Lisa Hartmann	A.R. Borneman, S.A. Schmidt	University of Adelaide, Wine Australia
Jana Hildebrandt	J.L. Hixson, I.L. Francis, M.J. Herderich, M.A. de Barros Lopes[1]	Wine Australia, Australian Government Research Training Program Scholarship
Mango Parker	I.L. Francis, M.J. Herderich, J.L. Hixson, M.A. de Barros Lopes[1]	Wine Australia, Australian Government Research Training Program Scholarship
Wes Pearson	I.L. Francis, J. Blackman[2], L. Schmidtke[2]	Wine Australia
Julie Tang	M.A. Whitty[3], N.A. Lee[3], P.R. Petrie[4]	Wine Australia, UNSW
Stipe Zekanovic	S.A. Schmidt, I. Dawes[5], G. Perrone[5]	Wine Australia, Western Sydney University
Gail Gnoinski	S.A. Schmidt, D. Close[6], F.L. Kerslake[6]	University of Tasmania
Yevgeniya Grebneva	M.J. Herderich, J.L. Hixson, M. Stoll[7], D. Rauhut[7]	Hochschule Geisenheim University, AWRI
Colleen Szeto	K.L. Wilkinson[8], V. Pagay[8], M.J. Herderich	ARC ITTC-2, University of Adelaide
Naomi Verdonk	K.L. Wilkinson[8], K. Pearce[1], R. Ristic[8], J. Culbert	University of Adelaide, Wine Australia
Yihe (Eva) Sui	K.L. Wilkinson[8], J.M. McRae	University of Adelaide
Wenyu (Wayne) Kang	S.E.P. Bastion[8], R. Muhlack[8], P.A. Smith[9], K.A. Bindon	University of Adelaide, Wine Australia
Qi Wu	S.D. Tyerman[8], N. Habili, F.E. Constable[10], A.R. Rinaldo	University of Adelaide, Wine Australia
Martin Moran	V.O. Sadras[4], S.E.P. Bastian[8], P.R. Petrie[4]	SARDI, University of Adelaide
Wendy Cameron	S. Fuentes[11], K.S. Howell[11], E.W.R. Barlow[11], P.R. Petrie[4]	University of Melbourne
MSc		
Lucy Kendall	P.R. Petrie[4], V.O. Sadras[4], M. Bonada[4]	Self-funded

Affiliations: [1]University of South Australia, [2]Charles Sturt University, [3]University of NSW, [4]South Australian Research and Development Institute, [5]Western Sydney University, [6]University of Tasmania, [7]Hochschule Geisenheim University, Geisenheim, Germany, [8]University of Adelaide, [9]Wine Australia, [10]Agriculture Victoria, [11]University of Melbourne

APPENDIX 6

Media interviews

Date	Staff member	Discussed	Media
4 Jul 2018	P.R. Petrie	Hyperspectral imaging for disease assessment at the weighbridge	Nick Carne, *Wine Australia R&D@work*
23 Jul 2018	W.P. Pearson	Shiraz terroir project	Mike Dunne, *Sacramento Bee*
2 Aug 2018	S. Nordestgaard	Harvesting destemmers	Chloe Szentpeteri, *Australian & New Zealand Grapegrower & Winemaker*
3 Aug 2018	A.R. Borneman	Bioprospecting project	Jacquie van Santen, *Wine Australia RD&E news*
6 Aug 2018		Shipwreck yeast	Tony Love, *The Advertiser*
14 Aug 2018	S. Nordestgaard	Presentation at WEA conference	Sonya Logan, *Wine & Viticulture Journal*
	C.S. Stockley	Light, regular alcohol intake reduces dementia risk	Tony Love, *The Advertiser*
15 Aug 2018	P.R. Petrie	El Niño and La Niña – impacts on grapegrowing and winemaking	Paul LeLacheur, *Australian & New Zealand Grapegrower & Winemaker*
28 Aug 2018	M.L. Longbottom	Water management in viticulture	Michelle Bouffard, *Meininger's Wine Business International*
	T.E. Siebert	Researcher profile	Jacquie van Santen, *Wine Australia R&D@work*
11 Sep 2018	I.L. Francis	AWRI flavour chemistry research	Dr Nina Notman, *Chemistry World magazine*
13 Sep 2018	P.R. Petrie	Adaptation to climate change	Tessa Nicholson, *New Zealand Winegrower Magazine*
27 Sep 2018	A.R. Borneman	Metagenomics	Max Allen, wine writer
9 Oct 2018	C.A. Varela	Ways to lower alcohol in winemaking	Eleanor Danenberg, *Australian & New Zealand Grapegrower & Winemaker*
	K.A. Bindon		
10 Oct 2018	A.R. Borneman	Bioprospecting project	Rachael Nell, *RIAus*
	M.P. Krstic	Glyphosates	Max Allen, wine writer
2 Nov 2018	R. Gawel	CO_2 in wine	Jacquie van Santen, *Wine Australia RD&E news*
5 Nov 2018	K.A. Bindon	Grape and wine quality specialist shares knowledge with the CRI's team	Macarena García, *Center for Research and Innovation,* Chile
14 Nov 2018	C.S. Stockley	Sulfites in Prosecco	Gillian Wolski, *tendaily.com.au*
19 Nov 2018	M.P. Krstic	Regional Program activities in Greater Victoria	Jacquie van Santen, *Wine Australia RD&E news*
28 Nov 2018	E.N. Wilkes	Methods for alcohol analysis	Farrah Pullman, *New Daily*
10 Jan 2019	I.L. Francis	Flavour compounds in wine	Darren Smith, freelance journalist
23 Jan 2019	A.D. Coulter	Instability issues in sparkling wines	Mark O'Callaghan, *Australian & New Zealand Grapegrower & Winemaker*
4 Feb 2019	M.P. Krstic	Plant and Food's launch at the Waite Campus	Eleanor Danenberg, *Australian & New Zealand Grapegrower & Winemaker*
7 Feb 2019	M.G. Holdstock	Yarra Valley seminar and Cabernet tasting	Casey Neill, *Mail News Group*
13 Feb 2019	M.P. Krstic, C.A. Simos	Smoke taint	Hugh Hogan, *ABC Tasmania*
			Mark Smith, *TasmanianTimes.com*
20 Feb 2019	M.P. Krstic		Emily Jarvie, *Australian Community Media*
22 Feb 2019			Huon Hooke, *huonhooke.com*

Date	Staff member	Discussed	Media
6 Mar 2019	M.P. Krstic	Stubble burning collaborative project	Stuart Taverner, *Barossa and Light Herald*
8 Mar 2019		Smoke taint	Amanda Ducker, *News Corp Australia*
22 Mar 2019			Sumeyya Ilanbey, *The Age*
26 Mar 2019		Smoke taint/stubble burning project	Richard Whitehead, *Beverage Daily*
8 Apr 2019	M. Essling	Triazole fungicides in viticulture	Felicity Carter, *Meininger's Wine Business International*
18 Apr 2019	E.N. Wilkes	Authenticity research	Eleanor Danenberg, *Australian & New Zealand Grapegrower & Winemaker*
14 May 2019	D.L. Johnson	Climate change	Jim Bittermann, *CNN*
			Dana Nigro, *Wine Spectator*
			Drinks Business
17 May 2019	M.J. Herderich	Terroir and soil	Alisa Bryce, freelance writer
20 May 2019	I.L. Francis, W.P. Pearson	Wine flavour research	Jane Faulkner, wine writer
18 Jun 2019	C.A. Simos	Smoke taint	Casey Warrener, *Halliday Magazine* and *Wine Companion*
25 Jun 2019	S. Nordestgaard	Vineyard and winery practices survey	Christine Webster, *Murray Valley Winegrowers newsletter*
28 Jun 2019	A.M. Mierczynska-Vasilev	Magnetic nanoparticles	Jacquie van Santen, *Wine Australia RD&E news*

APPENDIX 7

Papers published by AWRI staff recorded during 2018/2019

2006 Chen, L., Capone, D., Tondini, F.A., Jeffery, D.W. Chiral polyfunctional thiols and their conjugated precursors upon winemaking with five *Vitis vinifera* Sauvignon Blanc clones. *J. Agric. Food Chem.* 66(18): 4674-4682; 2018.

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2008 Godden P. Ask the AWRI: Understanding whole-bunch fermentation. *Aust. N.Z. Grapegrower Winemaker* (652): p. 63; 2018.

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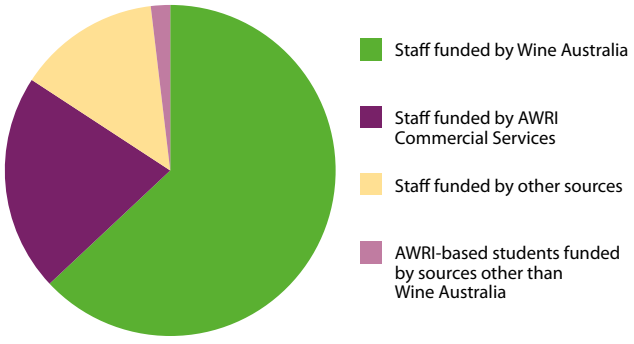

Figure 33. Funding of AWRI staff and students, excluding visiting researchers and visiting students

Staff of The Australian Wine Research Institute

(Left to Right)

FRONT ROW Kieran Hirlam, Mark Solomon, Michael Roach, Luca Nicolotti, Peter Godden, Darek Kutyna, Steven Van Den Heuvel, Tracey Siebert, Markus Herderich, Natalie Burgan, Mark Krstic, Marlize Bekker, Dan Johnson, Ella Robinson, Josephine Giorgio-Ion, Junko Nagashima, Lisa Pisaniello, Desirée Likos, Mango Parker, Mardi Longbottom, Jana Hildebrandt, Brigitte Lynch, Zung Do, Jessica Scudds, Matt Holdstock

SECOND ROW Sonya Henderson, Eleanor Bilogrevic, Amanda Ylia, Julie Culbert, Caroline Bartel, Radka Kolouchova, Jelena Jovanovic, Simon Schmidt, Elli-Marie Panagis

THIRD ROW Mary Likos, Heather Smith

FOURTH ROW Gina Sellars, Melisssa Aitchison, Ida Batiancila, Damian Espinase Nandorfy, Martin Day, Maryam Taraji, Yevgeniya Grebneva

FIFTH ROW Pamela Solomon, Leanne Hoxey, Gayle Baldock, Sheridan Barter, Laura Bey, Natoiya Lloyd

SIXTH ROW Thomas Hensel, Chris Day, Matthew Wheal, Jenny Bellon, Kara Paxton

SEVENTH ROW Marco Schoeman, Amy Rinaldo, Catherine Borneman, Simon Dillon, John Gledhill, WenWen Jiang

EIGHT ROW Marcel Essling, Robyn Gleeson, Nuredin Habili, Neil Scrimgeour, Mark Braybrook, Thomas Almond, Vilma Hysenaj

NINTH ROW Josh Hixson, Anne Lord, Bryan Newell, Jesse Hall, Randell Taylor, Angus Forgan, Anthony Borneman, Cristobal Onetto, Toni Garcia Cordente

RAILINGS Song (Luke) Qi, Flynn Watson, Allie Kulcsar, Kate Cuijvers, Wes Pearson, Alex Schulkin, Mark Rullo, Geoff Cowey, Leigh Francis, Tony Hoare, Adrian Coulter, Paul Henschke, Cristian Varela, Michael Downie, Richard Gawel

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