Annual Report 2021
The Australian Wine Research Institute

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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Cover artwork

This year's cover image reflects the AWRI's research on the effects of aeration in red wine fermentations, which has shown that aeration promotes 'red fruit' characters and suppresses 'reductive' characters and astringency.

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67th Annual Report - 30 June 2021
Presented to the Australian grape and wine community

Chair and Managing Director's report

Introduction

Following the major challenges of the previous year, 2020/2021 has seen some more positive news for the Australian wine industry, with excellent growing conditions and a record-breaking vintage. This has been tempered by the continued challenges in export markets after the imposition of tariffs by China. As COVID-19 restrictions ease around the world, it is hoped that the Australian wine community will be able to take advantage of more positive consumer sentiments and greater freedoms. At the AWRI in 2020/2021 there has been strong progress across a range of areas, with highlights in sustainability, industry support, smoke research, collaborations and new capabilities.

Advances in sustainability

In August 2020, Australian Grape & Wine, the AWRI and Wine Australia signed a Memorandum of Understanding outlining the collaborative arrangements for governance and delivery of the national sustainability program, Sustainable Winegrowing Australia. The formalisation of this collaboration has clarified the roles of the three organisations, strengthened the program and contributed to significant progress during the year. Membership increased by 23% to 631 in 2020/2021, split across 90% vineyard members and 10% winery members. Certified members currently represent 15% of total members and demand for the training needed to commence the certification process has also grown significantly. A new standalone website for the program was launched in April 2021, and planning commenced for a publicity campaign to continue to boost membership and highlight Australia's sustainability credentials to the global marketplace.

Smoke research and support

While Australia was fortunate not to have a high-risk fire season in 2020/2021, ongoing support was provided to those affected by the 2020 fire season, on an individual basis and via state-based programs. Some US producers, affected by severe fires along the western seaboard, also accessed the AWRI's analytical capabilities. Throughout NSW, Victoria and SA, assistance was provided to set up regional sensory panels for assessing 2020 wines and a new method for smoke sensory analysis was formalised. Results from research trials conducted on 2019/2020 Adelaide Hills samples showed that pre-veraison smoke exposure, previously thought to pose a low risk of smoke taint, did in fact result in both detectable smoke glycosides in fruit and 'smoky' aromas and flavours when the ripened fruit was made into wine. This major breakthrough will change the risk assessment for growers experiencing future fire and smoke events. Several AWRI staff were invited to present their work at the National Bushfire Conference in May, showcasing the AWRI's world-leading expertise in smoke taint research, diagnostics, sensory analysis and education.

Response to COVID-19

Impacts of the global COVID-19 pandemic have continued to be felt across Australia and around the world. Lockdowns, border closures and travel restrictions affected everyone, including the AWRI and the delivery of its national activities. Workplace policies and processes developed early in the pandemic have made it easier to adapt to changing conditions as the situation has evolved and staff have continued to demonstrate resilience and positivity when dealing with change.

Increased online presence/pivot to digital

A key aspect of the AWRI's response to the ongoing COVID-19 pandemic has been an increased focus on virtual platforms. A large percentage of extension events in the past year, including tastings, have been delivered online, working with new partners to ensure tasting samples can be efficiently sent to participants across Australia and received in good condition. Webinars have greatly increased in popularity, both in terms of live attendance and views of recordings on YouTube. Very strong increases have also been observed for views of the demonstration videos recorded over the past two years, confirming the usefulness of this virtual format. A new podcast, 'AWRI decanted', is in preparation, to further expand the AWRI's digital presence. In addition, the ShowRunner wine show and classification software has been completely transitioned to an online product, which allows show organisers to run the software themselves, no matter where in Australia they are located, with online support provided remotely by AWRI staff. International collaborations have also been maintained successfully through online meetings and conferences, along with ongoing contributions to international regulatory forums such as the International Wine Technical Summit, FIVS, World Wine Trade Group, the OIV and the APEC Wine Regulatory Forum.

Wine Australia - completion of independent performance review

The second stage of Wine Australia's independent expert review of its strategic partnership agreements with the AWRI and other research providers was completed during the year. This stage focused on the scientific and technical excellence of the outcomes achieved by research providers as well as industry impact, and included peer review by international scientists. The reviewers were overall very complimentary about the AWRI's excellence and impact, and recommended that a longer-term partnership arrangement be continued. Since the release of the review findings, the AWRI management team has been working closely with Wine Australia on the steps towards developing a new partnership agreement.

Strategic planning

In addition to the steps taken to prepare for a new agreement with Wine Australia, a range of other strategic planning activities were undertaken or commenced during the year. A management summit was held in March 2021 to develop a 2021-2023 version of *AWRI Directions,* the business and operational initiatives that guide the AWRI's continuous improvement. AWRI Commercial Services is developing a new strategic direction, which will support the sustainability of the AWRI into the future. A whole-of-business strategy has also been under development, coordinated by an external consulting company and informed by extensive stakeholder consultation. Finalisation, approval and implementation of the new strategies will flow into the next financial year.

Strengthened strategic relationship with the University of Adelaide

The AWRI's relationship with the University of Adelaide has always been a strong one, with the AWRI having been a tenant on the University's Waite Campus since its founding in 1955, and sharing its current Wine Innovation Central Building with the University's School of Agriculture, Food and Wine and SARDI. The AWRI and the University are also joint venture partners in WIC Winemaking Services. Over the past year that relationship has strengthened with the development of a new 'Friendship fund' for investment into joint projects, focusing on opportunities with potential to further leverage an initial investment and 'grow the pie' for wine research on the Waite Campus. Initial projects funded under this arrangement span topics including Shiraz disease, grape and wine organic acids, smoke taint and consumer purchasing behaviour in no- and low-alcohol product categories.

Proposed constitutional changes to Board appointments and composition

At Board level, significant work has been underway over the past 18 months to investigate options for improving Board composition and appointment processes, to ensure an appropriate balance of skill representation, industry connection and diversity. A number of initial consultations with industry have been held and more general input will be sought from stakeholders before any changes are implemented. The proposed changes would be the first substantive changes to Board composition and appointment processes since 2006. The Board believes these changes will ensure the AWRI is best placed to meet the evolving needs of the Australian grape and wine industry and continue to model contemporary principles of best practice corporate governance.

Leadership Development Program

The AWRI launched a new internal leadership development program this year with the goal of continuing to develop leadership talent within the organisation. The program provides participants with a range of practical experience, formal training and other opportunities for personal and professional growth. Four participants were selected as the first cohort for the program, which has a two-year term. New intakes will then be staggered to ensure an overlap of participants within the program, to provide continuity. Selection criteria include leadership potential and aspects of diversity including representation from across the AWRI's operational groups, gender, experience and background. This year's cohort has participated in a range of professional development courses and personal development activities, and were also tasked with organising the 2021 AWRI 'All staff day', centred around the theme of resilience.

Preparation for the 18th AWITC

Planning and preparations are well underway for the 18th Australian Wine Industry Technical Conference and Trade Exhibition to be held in Adelaide from 26 to 29 June 2022. Once again the AWITC is partnering with Australian Grape & Wine's Outlook conference, with Outlook sessions to form the first three sessions of the plenary program. Program themes will include the wine industry's licence to operate, a roadmap for sustainability, vineyard health, wine innovation and new technologies. A comprehensive workshop program, technical poster display, student forum and networking functions will form part of the conference experience.

AWRI Commercial Services

AWRI Commercial Services had another strong year with the laboratories analysing a total of 28,710 samples in 2020/2021, 16% higher than the three-year historic average. Smoke taint analysis numbers remained high at 4,252 samples (of which 49% were from the USA), much higher than the longer-term average of 600 samples. New instrumentation was validated for the determination of smoke glycosides, and changes were made to allow graphical representations of results to be automatically included in reports, allowing easier interpretation and reducing turnaround times. Demand for biological services continued to increase, in particular for microbiological analyses. During the year the applied biosciences team focused on modernising and streamlining the systems used for virus detection and undertook cross-validation studies with the other major virus testing laboratory in Australia, demonstrating good alignment of laboratory protocols and results. Commercial Services' small-scale packaging facility also expanded and now includes the ability to incorporate bottles, kegs and cans of varying sizes and formats, as well as a range of different closure application tools. The breadth of sensory services being offered to industry was also increased to incorporate rapid profiling methods such as napping and Pivot©profile.

Working with Maggie Beer – new product development from apples and pears

An opportunity arose to work with well-known food producers Maggie and Colin Beer on projects designed to extract value from heritage apple and pear orchards. After an expression of interest and pitch process, two small projects were selected for internal funding. The first aims to develop apple flour from pomace waste streams. The second aims to conduct a malolactic bacteria strain selection exercise to develop a kombucha from apple juice and a fermented apple sauce/puree from the pomace waste stream. These projects were very well received by Maggie and Colin Beer, and have generated much creativity from the project teams involved, with valuable experience gained of the factors involved in new product development.

Genomics partnership

The AWRI is a partner in the South Australian Genomics Centre (SAGC) – a state-wide genomics facility established in July 2020 as part of a $7m investment in genomics and bioinformatics, including $2m from Bioplatforms Australia. The SAGC provides a state-of-the-art fee-for-service genomics facility with an integrated bioinformatics platform to support users in the complex analysis of the data generated. The SAGC is governed by an Advisory Board made up of an independent chair and a nominee from each partner institute, including the AWRI. The facility aims to maximise access to genomic sequencing technologies and bioinformatics support through outreach, education and training and create new cutting-edge research opportunities by enhancing connections between researchers, genomics user groups and bioinformatics experts. The AWRI expects to work closely with the SAGC in future projects, including planned work on grapevine genomics.

New capabilities

The AWRI continues to invest in capabilities to benefit the Australian grape and wine sector. A major acquisition during the year was a liquid state 400 MHz nuclear magnetic resonance (NMR) instrument, installed in new laboratory space on level 1 of the Wine Innovation Central Building. This brings new capability which can be used for both targeted and non-targeted analysis, and has already been successfully applied in quantification of amino acids in wine. At WIC Winemaking Services a new bottling line has brought major benefits in efficiency and reductions in downtime. New capabilities to deliver trials for brewing and distillation have also been developed, reflecting demand for diversification within our industry, where many wineries now also conduct craft brewing or distillation activities.

Technical trends from the AWRI helpdesk

As in previous years, the queries received by the AWRI helpdesk reflected technical issues encountered during the year and were strongly influenced by the weather conditions of the growing season and vintage. In late September 2020, the Bureau of Meteorology declared that a La Niña event would occur during the 2020/2021 growing season and bring with it wetter than average conditions. The La Niña peaked in late January 2021 and became inactive by March 2021. This saw above-average rainfall throughout much of

Victoria, the Hunter Valley, the west and south of NSW and southern SA, particularly from December 2020 to January 2021. In many regions the rains provided relief from the extended drought that had been experienced on the east coast, replenishing vines, water storages and stream flows. The La Niña event brought generally cooler growing conditions across south-eastern Australia, contributing to a slow and delayed ripening season. South Australia had its coolest summer in 19 years. Western Australia, after a dry winter in 2020, also reported a cool and wet spring followed by a mostly dry summer, but with some summer rain events causing humidity. The WA summer was the coolest in the last 15 years, with harvest extending into April.

Due to the generally cooler and longer ripening season, many producers experienced even ripening, with fruit flavour and tannin ripeness occurring before sugar ripeness. Fewer heatwaves and an extended growing season also saw fewer stuck fermentations and associated problems. Higher acidity levels (and in many cases double the typical concentrations of malic acid) were reported by some producers, resulting in high initial titratable acidities in must and larger than usual pH increases post-malolactic fermentation. Overall, producers reported both exceptional fruit quality and high yields. Wine Australia's national vintage survey estimated an Australian wine-grape crush of 2.03 million tonnes, the largest ever recorded, 17% above the 10-year average of 1.74 million tonnes.

Bushfires and planned burns

Thanks to the cooler season, there were fewer extreme temperature days and a generally lower risk of bushfires – a welcome relief after the 2020 season. Despite this, fires did occur in some regions of SA and WA. A forecast wetter 2021 winter raised the potential of a shorter window of opportunity to conduct planned burns to reduce bushfire risk. Several states therefore brought forward the start of their burns to early March, which caused concerns from neighbouring wine regions with fruit still on the vine. The AWRI worked with state and regional bodies to provide accurate information on controlled burns and their impact on viticulture to support communications with organisations conducting burns. A large number of queries on smoke taint answered by the helpdesk related to wineries processing 2020 wines and investigations of smoky sensory characters developing in wine after time in bottle.

Biosecurity

The pest insect fall armyworm, *Spodoptera frugiperda*, was first detected in northern Queensland in January 2020 and later in NSW in November 2020. This highly invasive pest has the potential to feed on grapevines but its behaviour is not well understood. Chemical controls were made available via Australian Pesticides and Veterinary Medicines Authority permits but were not required. The AWRI produced two eBulletins to communicate to industry about this new pest, including options for its control.

Looking towards vintage 2022

The El Niño–Southern Oscillation (ENSO) system is currently neutral but the chance of a La Niña event forming in the coming months has increased. This may increase the chance of above-average rainfall from November to January for the eastern two-thirds of Australia, as well as northern and south coast areas of WA.

At the AWRI, 2021/2022 will see:

- Conclusion of a suite of Wine Australia-funded research projects and continued refinement of a project portfolio for a new investment agreement with Wine Australia
- Ongoing strategy development and implementation, particularly for AWRI Commercial Services
- Delivery of the 18th Australian Wine Industry Technical Conference and Trade Exhibition in conjunction with the Australian Society of Viticulture and Oenology, Australian Grape & Wine, Wine Industry Suppliers Australia Inc. and Expertise Events.
- Voting on the proposed changes to the AWRI's constitution to implement changes to Board composition and appointment processes at a Special General Meeting.

Board and staffing changes

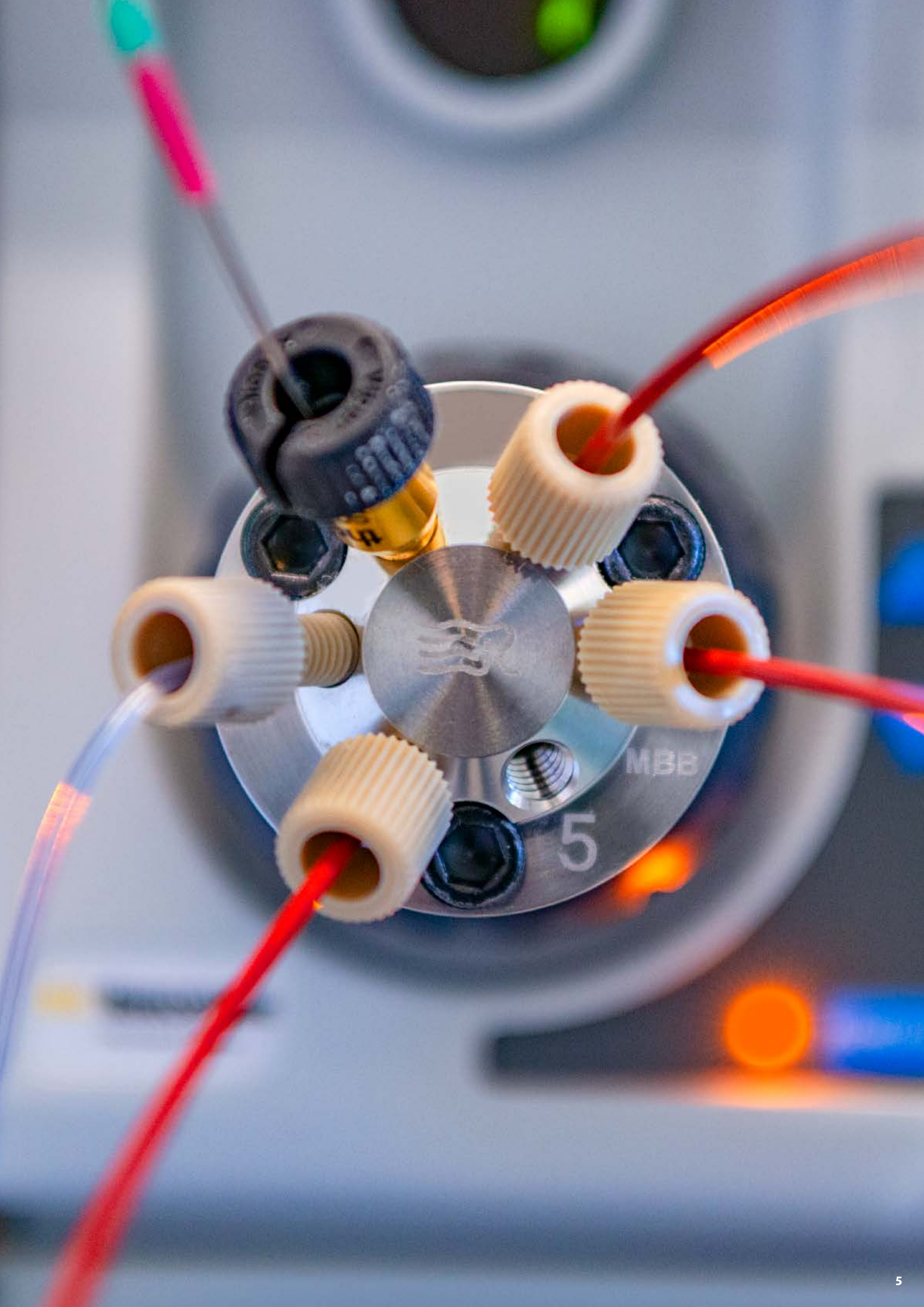
During the year the Board gained four new members, Trish Giannini, Corrina Wright, Brett McClen and Nigel Sneyd, and bid farewell to Mark Watson, Iain Jones, Wendy Cameron and Marcus Woods. In August 2020, the AWRI welcomed Dr Tony Robinson into the position of Business Development Manager, where he is bringing a fresh approach to managing a wide range of opportunities for the organisation. In June 2021, long-standing staff member Peter Godden was farewelled after 24 years of service supporting industry, delivering extension and managing applied research, development and engagement activities. We wish Peter the very best with his next endeavours.

Expressing our thanks

Every year the AWRI works closely with numerous grapegrowers and winemakers across Australia, provides services to a wide range of commercial clients and investment partners, and operates more than 100 active research collaborations. Grateful thanks are expressed to each of those partners, who all contribute to the ongoing success of our industry. Australian Grape & Wine and Wine Australia provide essential strategic and financial support to the AWRI and are warmly acknowledged for their contributions. Members of the AWRI Board, both long-standing and recent, are thanked for their commitment and enthusiasm during the year. And finally, the dedicated and talented group of people who make up the AWRI staff are gratefully recognised for their passion, hard work and resilience in service of our industry.

Louisa E. Rose
Chair

Dr Mark P. Krstic
Managing Director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Pictured left to right: Trish Giannini, Mark Krstic, Corrina Wright, Toby Bekkers, Kiaran Kirk, Liz Riley, Nigel Sneyd, Louisa Rose. Absent: Brett McClen

Board members

Ms L.E. Rose
BAppSc (Oen), BSc, GAICD
Chair – Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Mr T.J. Bekkers
BAppSc (Ag) (Hons), Grad Cert (Mgt)
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Ms W. Cameron MW
(until 31 December 2020)
BAppSc (Biochem and Microbiol), MSc, BAppSc (Wine Sci), GradDip (Ed), GradCert (Bus)
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Ms P. Giannini
(from 16 September 2020)
BEc, GradDipAcc, ICAA
Elected under Clause 25.2(b) of the Constitution
(Special Qualification Director)

Mr I.M. Jones
(until 31 December 2020)
BSc, MSc
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

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

Dr M.P. Krstic
BAgSc (Hons), PhD, MBA, GAICD
Ex officio under Clause 25.2 (a) of the Constitution as Managing Director of the AWRI

Mr B.M. McClen
(from 1 January 2021)
BAgSci (Hons), MBA
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Ms E.A. Riley
BAppSc (Wine Science)
Elected under Clause 25.2 (b) of the Constitution
(Special Qualification Director)

Mr T.N. Sneyd MW
(from 1 January 2021)
BAppSc (Wine Science), DNO, MBA
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Mr M.R. Watson
(until 31 December 2020)
BEc, MBA, CA, RITP, MAICD
Elected under Clause 25.2 (b) of the Constitution
(Special Qualification Director)

Mr M.Y. Woods
(until 14 March 2021)
BAppSc (Vitic), MBA
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Ms C.N. Wright
(from 1 January 2021)
BCom, BAgSc (Oen)
Elected under Clause 25.2 (c) of the Constitution
(Levy Payer elected Director)

Board notes

Chair
Ms L.E. Rose

Audit committee
Ms P. Giannini (Chair), Mr T.J. Bekkers, Mr B.M. McClen

Personnel committee
Ms L.E. Rose (Chair), Mr M.Y. Woods (until 14 March 2021), Prof. K.D. Kirk, Mr T.N. Sneyd (from 1 June 2021)

Meetings

Ordinary General Meeting
The 66th Ordinary (Annual) General Meeting was held on 24 November 2020.

Board
The Board of the AWRI met on the following dates: 16 and 17 September 2020; 23 and 24 November 2020; 23 and 24 February 2021; 31 May and 1 June 2021.

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, Water and the Environment; and Bioplatforms Australia, along with a large number of confidential commercial clients. The AWRI is committed to investing the funding it receives from Wine Australia in accordance with the performance principles for Research and Development Corporations set out by the Australian Government.

Appreciation

The AWRI benefits greatly from collaborations with individuals and organisations from the following countries: Australia, Bulgaria, Canada, China, France, Germany, Indonesia, Italy, South Africa, UK and USA. The assistance and cooperation provided by these partners across the globe are gratefully acknowledged.

Highlights of the year

Customers, consumers and markets

International working group on the impacts of smoke on wine

The AWRI is chairing a FIVS Scientific and Technical Committee working group on the impacts of smoke on grape and wine production. This group is working on formulating international guidance on research priorities, defining chemical markers for analysis of smoke impacts, developing performance criteria for laboratories offering smoke testing and coordinating an international laboratory proficiency testing program.

Energy content calculations investigated

In response to pressure to provide consumers with more information, data from large numbers of samples was analysed to understand contributions to energy content from different wine components. Results showed that the dietary energy content of wine can be calculated to an appropriate degree of accuracy based on measured values of alcohol and sugar, combined with generic values for the glycerol and organic acids. Further investigations showed that generic values for energy content are also an acceptable option for most wine styles.

Updated agrochemicals app launched

Work on the AWRI's databases of agrochemical and maximum residue limit (MRL) information allowed them to be merged into a single system. This change has improved the functionality of the AWRI's online search facility and supported the launch of an updated agrochemical app, which allows users to perform agrochemical and MRL searches from a single platform.

Support for registration of new agrochemicals

Support was provided for the registration of four new active constituents (eugenol, geraniol, thimol and fluopyram) for use in wine-grape production. Data on their impact on fermentation, sensory properties and residues were assessed and decisions about withholding periods were made by the Agrochemical Reference Group.

Strategies for managing mancozeb residues developed

Targeted analysis of selected wines and collaboration with a chemical manufacturer on vineyard trials provided greater understanding of the residue profile of mancozeb in Australian wine, enabling development of informed strategies to manage residues.

Extension, adoption and education

Webinars

Twenty-one webinars were presented to a total of 2,199 attendees – a 67% increase in attendance from the previous year. Views of webinar recordings on the AWRI's YouTube channel also increased significantly from 19,400 views in 2019/2020 to 53,499 views in 2020/2021.

Seminars and workshops

Seven roadshow seminars and eleven workshops were presented in 2020/2021 to a total of 337 attendees, in a mix of face-to-face and virtual formats.

Website

More than 177,525 visitors accessed the AWRI website during the year with more than 604,635 page-views. New content was added on topics including smoke taint (particularly following early-season smoke exposure), sustainability, vineyard management practices and brown marmorated stink bug biosecurity.

Wine education

For the first time, three Advanced Wine Assessment Courses were delivered in successive weeks, providing 48 attendees with the opportunity to improve their tasting skills and gain a greater understanding of wine show judging.

Videos and podcasts

Following the success of the previous year's pilot video project, four new videos were produced and uploaded to the AWRI's YouTube channel. Demonstration videos on the AWRI's YouTube channel were viewed more than 69,900 times, illustrating the popularity of this format. A pilot program of podcasts was also initiated during the year. Three podcast episodes were recorded with AWRI researchers on the topics of Australian Shiraz terroir, 'stone fruit' flavour and the use of oxygen during fermentation, with four additional episodes scheduled for recording early in the new financial year. The podcasts will be released as a flavour-themed series in the lead-up to vintage 2022 under the title 'AWRI decanted'.

Online viticulture content

A restructure of viticulture content on the AWRI website was completed, making it easier for growers to find relevant information.

Refreshed winemaking calculators app

A refreshed version of the AWRI's popular winemaking calculators app was released, offering a new total package oxygen calculator and an improved fining trial calculator.

ShowRunner migration

The AWRI's all-in-one wine show management platform, ShowRunner, was migrated to a completely online version that allows wine shows to operate the software without an AWRI staff member present. Support is provided from a central location, minimising travel costs and allowing multiple shows to be supported at the same time. Nineteen wine shows used the platform in the COVID-19-disrupted 2020 wine show season.

Helpdesk support

The AWRI helpdesk responded to 2,431 enquiries in 2020/2021, fewer than the long-term average. The observed drop in enquiry numbers is likely due to the nearly ideal growing conditions, which led to a vintage of exceptional fruit quality. Sustainability enquiries continued to grow, almost doubling compared to last year, and reaching more than 1,000 for the first time.

Practice change focus

New practice change priorities of oxygen use in winemaking and irrigation efficiency were identified through consultation with Wine Australia and industry stakeholders. Programs of activities and packaged materials to promote adoption of these practices were launched during the year, including irrigation workshops held with producers in the warm inland regions.

Library services

In 2020/2021 the library responded to 1,059 reference and information requests and delivered 2,474 articles in response, similar numbers to the previous year. The number of articles requested from the current literature presented in *Technical Review* increased by 137. The number of requests for resources from online information packs increased by more than 30%, with 213 more articles delivered than the previous year. Usage of the staff publication database also increased by 17.5%. Library staff performed 30 specialised literature searches on a variety of topics across winemaking, vineyard management, winery operations and pest management.

Performance, products and processes

Nitrogen and sulfur foliar sprays trialled in commercial vineyards

Trials with industry partners assessed simple foliar sprays under commercial conditions in Chardonnay and Sauvignon Blanc vineyards in Padthaway. Positive feedback has been received on the effects on wine flavour and the practicality of the spray regime required. This topic has been proposed as a potential future practice change priority.

New analytical methods for 'raisin'/'jammy' flavour compounds in ripe Shiraz

'Dried fruit' and 'jammy'/'cooked fruit' sensory attributes in warm climate Shiraz grape berries were related to specific volatile compounds, and new analytical methods to quantify their levels were developed.

Rapid method for amino acid quantification

Using the newly acquired nuclear magnetic resonance instrument, a simple and rapid method requiring minimal sample preparation has been developed to measure the concentration of specific amino acids that are related to desirable flavour properties in red wines.

Improved prediction of bottle ageing outcomes

The kinetics of release of monoterpene 'floral'/'citrus' aroma compounds from glycosides was characterised, which will assist future accelerated ageing studies to better predict outcomes following bottle storage.

Further understanding of bitterness and 'savoury' character in wine

The bitter tasting compound tryptophol sulfonate is only likely to be perceived by sensitive tasters in white wines produced with high levels of its precursors tryptophol and SO_2. Tryptophol sulfonate formation does not occur after bottling in red wines to any practical extent, most likely due to binding of SO_2 by red wine components. A potentially new bitter compound in wine was identified and a preparative-scale synthesis method was developed and implemented to achieve sufficient quantities for sensory assessment. The concentration distributions and ranges in Australian wines of potential contributors to 'savoury' character were determined for use in future investigations.

Anthocyanin's role in cold stability of red wines revealed

Monomeric anthocyanin is critical to protect red wines from cold instability, and its conversion to other forms during wine processing may underpin late-stage cold instability issues.

Ongoing advances in heat stabilisation

A fluorescent dye specific to haze-forming proteins in white wine provides a new, rapid screening tool for heat instability.

Maceration technique improves low-phenolic red grapes

Accelerated maceration was found to enhance the extraction of colour and tannin from grapes of low phenolic potential.

Aeration effect in white 'wild' ferments explored

Aeration of white non-inoculated ferments was shown to reduce fermentation times with minimal changes to wine composition.

No- and low-alcohol project launched

Sensory assessment of more than 90 no- and low-alcohol products was completed to better understand the product category. An industry reference group was established to help guide this new project.

Interspecific hybrids investigated

The heritability of the low acetic acid production trait in an *S. cerevisiae* x *S. uvarum* hybrid was demonstrated, and the genetic basis of the trait was shown to be related to the retention of a single chromosome. In addition, a direct comparison of seven interspecific yeast hybrids in red wine production was completed, allowing hybrid yeasts that appear well suited to red wine production to be identified.

High-thiol-producing yeasts are not just for white wines

High-thiol-producing yeasts, previously thought of as tools for the production of white wines such as Sauvignon Blanc, were shown to be suitable for the production of red wines. Thiol compounds that contribute 'tropical' characters in white wines were shown to increase 'red fruit' characters in Pinot Noir and Grenache.

Further understanding of *Oenococcus oeni*'s stress response

Analysis of *Oenococcus oeni*'s response to SO_2 demonstrated that these bacteria have minimal capacity to deal directly with higher SO_2 concentrations but instead rely on general stress response mechanisms to deal with the damage caused.

New understanding of co-inoculation

Transient acetaldehyde production by yeast has been correlated with *O. oeni* survival during yeast/bacteria co-inoculation. It appears this may help to protect *O. oeni* against elevated SO_2 concentrations. In addition, strain-specific fitness profiling of *S. cerevisiae* yeasts has shown that some strains are more able to cope with environments where other genera of yeasts are resident. This work has implications for the application of non-*Saccharomyces* yeast as co-inoculants in fermentations.

Insight into terroir

Analysis of historical grape compositional data has shown that non-targeted analytical approaches can effectively overcome within-vineyard or sub-regional variation, providing a stronger 'chemical fingerprint' to define terroir.

New project addressing ACCC grape market recommendations

A range of standardised methods for grape assessments were developed including for total soluble solids, pH, titratable acidity and colour, to address situations where these measurements are used as part of the criteria for setting payment or rejecting grapes. Protocols were also developed for sampling in vineyards, in wineries and at the weighbridge; the assessment of matter other than grapes (MOG) at the weighbridge; and the evaluation of wines for the presence of specific sensory attributes, particularly those arising from the effect of smoke in vineyards.

Further understanding of SO_2 tolerance in *Brettanomyces*

Sulfur dioxide-tolerant industry isolates and laboratory-evolved SO_2-tolerant strains were both shown to have amplification of the SO_2-transporter (*SSU1*) gene, indicating that this may be a key aspect in the development of tolerance to this important antimicrobial preservative. This discovery will help guide future work.

Exploring the influence of yeast strain and yeast genetics on unwanted sulfur compound formation

Of 15 yeast strains screened in Pinot Noir must only one produced quantifiable benzylmercaptan (the compound responsible for 'struck flint' character in wine), and this correlated with the H_2S production of the strains. Three alternative genes to yeast alcohol acetyltransferase (*ATF1*) have been identified that might be responsible for the formation of the undesirable volatile sulfur compounds, methanethiol and methylthiolacetate.

New canning capability

AWRI Commercial Services has developed a state-of-the-art small-scale canning unit that can be used to package wine-based products into can with best-practice packaging processes.

Effects of early-season smoke exposure confirmed

Research conducted during the 2019/2020 bushfire season showed that pre-veraison smoke exposure can result in increased smoke markers in grapes and wine, and noticeable 'smoky' attributes in wine. Content on the AWRI website and in fact sheets was updated to reflect these findings, which contradicted earlier beliefs about the risk of early-season smoke exposure.

Assessment of smoke markers

The existing suite of smoke markers was found to predict 'smoky' flavour well, with a high degree of correlation between smoke markers, based on 23 Adelaide Hills wines and an additional 42 wines made from smoke-affected grapes from SA, NSW, ACT and Victoria.

Environment, sustainability and natural capital

Sustainable Winegrowing Australia website and trust mark

A new standalone website for Sustainable Winegrowing Australia was launched in April 2021. The program trust mark completed registration with IP Australia in December 2020 and has been accepted in the EU, UK, NZ and the USA. During the year, 17 applications for use of the trust mark on wine labels by certified members of the program were approved and 38 farmgate signs featuring the trust mark were delivered to certified members.

Grants to support sustainable winegrowing

The AWRI assisted with several successful grants to support the adoption of Sustainable Winegrowing Australia in Langhorne Creek, the Barossa, Adelaide Hills, McLaren Vale and Margaret River.

Clonal mapping of Pinot Noir

Key sources of Pinot Noir germplasm have been targeted for whole-genome sequencing in collaboration with Adelaide Hills Vine Improvement Incorporated. Clonal identification will be determined through assessment of clone-specific genetic variation.

Mapping the microorganisms in a winery

The ability of metagenomic techniques to map winery-resident micro-flora was demonstrated. Key findings were that microbial communities changed over time and space, and that some populations persisted over several months. It was also possible to identify locations inhabited by spoilage microorganisms, which could be targeted with cleaning procedures to reduce the risk of wine spoilage.

Late harvest date key to high 'pepper' concentration

A very late harvest date was demonstrated as being key to achieving elevated grape rotundone concentrations. This is because extensive formation of the immediate rotundone precursor α-guaiene, and subsequently rotundone itself, typically only commences well after veraison. The importance of harvest date provides an explanation as to why higher grape rotundone, and consequently 'peppery' aromas in wine, are typically found in very high premium Shiraz from cool-climate regions where such late harvest is commercially viable.

Trunk disease genomic variation assessed

Genome sequences have been obtained for 44 isolates of *Eutypa lata*. Patterns of genetic variation are being used to investigate associations with key markers of pathogenicity.


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Foundational data and support services

Continued growth for AWRI Commercial Services
In 2020/2021, the Commercial Services laboratories processed 28,710 samples, 16% higher than the 2018-2020 average of 24,754. A total of 212 new customers were added.

Strategy development
A range of strategic planning activities were undertaken during the year. A management summit was held in March 2021 to develop a 2021-2023 version of *AWRI Directions,* the business and operational initiatives that guide the AWRI's continuous improvement. AWRI Commercial Services is developing a new strategic direction, which will support the sustainability of the AWRI into the future. A whole-of-business strategy is also under development.

Leadership development program introduced
During the year the AWRI introduced an internal Leadership Development Program. With an inaugural cohort of four staff from across the AWRI's operational groups, this program aims to provide high-performing staff who exhibit leadership potential with a range of practical experience, formal training and other opportunities for personal and professional growth.

Review of Board composition and appointment processes
The AWRI Board commenced a review of its composition and Director appointment processes, seeking to ensure that it continues to apply best corporate governance practices which effectively balance skill representation, industry connection and various dimensions of diversity in the composition of its Board. Following a period of stakeholder consultation, the outcomes of this review are expected to be implemented in 2022.

Collaboration with University of Adelaide
The AWRI and the University of Adelaide developed a 'Friendship fund' for joint projects, focusing on opportunities with potential to further leverage an initial investment and 'grow the pie' for wine research on the Waite Campus. Initial projects funded under this arrangement span topics including Shiraz disease, grape and wine acids, smoke taint and consumer purchasing behaviour for no- and low-alcohol products.

Strategic IT achievements
The remaining elements of the AWRI's *IT Strategic Plan 2019-2021* were substantively delivered, including the enhancement of network capabilities, an expanded back-up program and a range of IT security enhancements. A replacement *IT Strategic Plan* is expected to be developed over the next year.

NMR laboratory
A new liquid state 400 MHz nuclear magnetic resonance instrument was commissioned in 2020/2021. This platform provides high-throughput metabolite screening, structural elucidation and accurate quantitation of metabolites in biological samples.

New microbe strains characterised
A number of strains with unusual fermentation properties were characterised by the AWRI Wine Microorganism Culture Collection with potential for use in wine production and other industries. These included a hybrid *Saccharomyces* yeast with high sorbitol fermentation potential, which may be useful in the pharmaceutical industry, and a yeast isolate that appears to ferment fructose but not glucose, which may be useful in low-alcohol beverage production.

Rapid smoke screening trialled
Initial trial work has been completed on the application of mid-infrared spectroscopy for screening potentially smoke-affected grape samples. This rapid method shows promise in identifying very clean or highly smoke-affected samples and could reduce the numbers of samples that need the more time-consuming mass spectrometric analysis, decreasing instrument congestion and getting results to clients more quickly.

Expanded sensory capacity
Expanded sensory panel capacity has been achieved with 20 new part-time dedicated sensory panellists recruited from the local community. The assessors have been used for smoke sensory assessments and quantitative descriptive analysis projects.

New equipment and capabilities for WIC Winemaking Services
A new bottling line was installed in the Hickinbotham Roseworthy Wine Research Laboratory, suitable for both conventional and research winemaking volumes. A new capability to conduct brewing and distillation trials (both small-batch and pilot-scale) has been launched.

Acknowledgements
Edited by Ella Robinson, Kate Beames and Mark Krstic

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Design by Geoffrey Reed Communications

Photography by Jacqui Way Photography

Staff

The number of AWRI staff employed in a full-time, part-time and casual capacity as at 30 June 2021 was 136 (106.4 full-time equivalents). When the number of AWRI-based students (both from Australia and overseas) and visiting researchers is added, the total increases to 137. Of these, approximately 62% were funded by Wine Australia in 2020/2021.

Office of the Managing Director

Mark Krstic, BAgSc (Hons), PhD *UniTas*, MBA *MelbBusSchool*, GAICD, Managing Director

Shiralee Dodd, BA, LLB (Hons), GradDip (Legal Prac) *UniAdel*, Company Secretary

Mardi Longbottom, BAgSc (Vitic Sci), MVit, PhD *UniAdel*, Manager – Sustainability and Viticulture

Ella Robinson, BA, BSc (Hons) *UniAdel*, Communication Manager

Tony Robinson, BSc (Hons) (Hort and Vitic) *UniWA* and *UniAdel*, PhD *Murdoch*, Business Development Manager (started 17 August 2020)

Kate Hardy, BA, LLB (Hons), GradDip (Legal Prac) *UniAdel*, GAICD, Legal Advisor

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Corporate Services

Chris Day, BAgSc (Oen), MBA *UniAdel*, GradCert Chartered Accounting Foundations *Deakin*, CA, GAICD, Group Manager – Corporate Services

Mark Braybrook, Cert IV (Eng and Mech Trade) *TAFE*, Operations Manager (concluded 4 September 2020)

Angus Forgan, BSc (Hons) *Flinders*, Operations and Research Laboratory Manager

Kate Beames, Cert IV (Small Bus Mgt) *Adelaide New Enterprise Training Services*, AWITC Conference Manager

Adam Holland, Cert IV (IT) *NTUni*, IT Manager

Alfons Cuijvers, MLaw *UniAntwerp*, Human Resources Coordinator

Catherine Borneman, BBus (Acc) *RMIT*, CA, Accountant

Fang Tang, Undergrad (Foreign Econ) *RenminUniChina*, GradDip (Fin Mgt), MCom *UniNewEng*, Finance Officer

Pauline Jorgensen, Cert III (Bus Admin) *TAFE SA*, Finance Officer

Kylee Watson, Cert III (Fin Services) *TAFE SA*, Finance Officer

Josephine Giorgio-Ion, Receptionist

Jennifer O'Mahony, Receptionist

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Michael Roach, BBiotech (Hons), PhD *Flinders*, Research Scientist (concluded 24 December 2020)

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Chris Ward, BSc (Hons) (Genet and Evol) *UniAdel*, Senior Scientist (started 15 March 2021)

Caroline Bartel, BSc (Hons) (Biotech) *UniAdel*, Scientist

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Flynn Watson, BSc (Hons) (Double Chem) *UniAdel*, Scientist

Melissa Aitchison, BAgSc (Oen) *UniAdel*, Technical Officer (concluded 13 August 2020)

Kate Cuijvers, BSc (Hons) (Genet) *UniAdel*, Technical Officer

Simon Dillon, BSc (Hons) *Flinders*, Technical Officer

Laura Hale, BSc (Genet), BSc(Hons) (Evol and Paleobiol) *UniAdel*, Technical Officer (started 27 January 2021)

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Radka Kolouchova, AssocDip *TechCollFoodTech*, Technical Officer

Renata Kucera, BSc (Hons) (Foren and Analyt Chem) *Flinders*, Technical Officer (started 16 November 2020)

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Tim Reilly, BSc (Hons) (Nanotech) *Flinders*, Technical Officer

Steven Van Den Heuvel, BSc (Hons) (Molec Biol) *Flinders*, Technical Officer

Jelena Jovanovic, Purchasing Officer

June Robinson, Laboratory Assistant

Metabolomics South Australia

Natoiya Lloyd, BSc (Hons) *Flinders*, PhD *UniAdel*, Node Manager Metabolomics SA

Luca Nicolotti, M (Chem and Pharmaceut Technol), PhD *UniTurin*, Research Scientist

Don Teng, PostGradDip (Math and Stat), MSc (Bioinform) *UniMelb*, Bioinformatician (started 19 October 2020)

Vilma Hysenaj, BSc, M (Pharm Chem), PhD (Food Chem) *UniGenova,* Post Doctoral Research Scientist

Maryam Taraji, BSc (Appl Chem) *UniGuilan,* MSc (Analyt Chem) *Al-Zahra*, PhD *UniTas*, Post Doctoral Research Scientist

Georgia Davidson, BSc (Hons) (Foren and Analyt Chem) *Flinders*, Technical Officer (started 26 October 2020)

Casual sensory panel

Nina Blake, Junko Blaney, Amy Cantor, Allison Cox, Amanda Dalton-Winks, Sara Davis, Penelope Elliot, David Evans, Penelope Fox, Josephine Giorgio-Ion, Cameron Grant, Philippa Hall, Sonya Henderson, Mary-Jane Hendry, Carrie Hill, Gurinder Khera, Mary Likos, Beverley Kiil, Susan Lincoln, Wai (Patrick) Liu, Rosemary McCarron, Dimple Melwani, Kerin Montgomerie, Liam O'Mahony, Virginia Phillips, Pierre Rafini, Sue Robinson, Jane Schapel, Makiko Sheehy, Heather Smith, Corey Spencer, Jacqueline Stone, Volker Trede, Susan Zabrowarny, Matthew Zdenkowski

Industry Development and Support

Con Simos, BAppSc (Oen) *UniAdel*, MBA *UniSA*, Group Manager – Industry Development and Support

Peter Dry, BAgSc, MAgSc, PhD *UniAdel*, Emeritus Fellow

Linda Bevin, BBus (Info Mgt), GradDip (Lib and Info Stud) *QUT*, Information and Knowledge Manager

Yoji Hayasaka, DipEng (Ind Chem) *Tokyo IT*, MPharm *Victorian College of Pharmacy Monash*, PhD *Yamanashi*, Senior Research Scientist – Mass Spectrometry (concluded 10 July 2020), Honorary Fellow

Adrian Coulter, BSc *Flinders*, GradDip (Oen) *UniAdel*, Senior Oenologist

Geoff Cowey, Dip *WSET*, BAppSc (Wine Sci) *CSU*, BSc (Hons) *UniAdel*, Senior Oenologist

Matt Holdstock, BSc *Flinders*, GradDip (Oen) *UniAdel*, Senior Oenologist

Ben Cordingley, BSc (Hons) (Biotechnol) *UniNSW*, BWineSc *CSU*, Oenologist (started 3 August 2020)

John Gledhill, BAppSc (Wine Sci and Vitic) *CSU*, Winemaker

Robyn Dixon, BSc, GradDip (Vitic) *UniAdel*, MAppSc *Lincoln*, Senior Viticulturist (started 2 November 2020)

Marcel Essling, BBus *Victoria*, BAgSc *UniAdel*, Senior Viticulturist

Chris Penfold, MAppSci (Ag) *UniAdel*, Senior Viticulturist (started 15 February 2021)

Liz Pitcher, BAgSc (Hons) *UniAdel*, BAppSc (Vitic) *CSU*, Sustainability and Viticulture Specialist (started 8 February 2021)

Lieke van der Hulst, BSc *Leiden,* MSc *TechUniDelft*, PhD *UniAdel*, Assistant Winemaker

Francesca Blefari, BBus *UniEdithCowan,* Events and Projects Manager

Anne Lord, GradDip (Info Stud) *UniSA*, Librarian

Michael Downie, BA (Hons) *UniAdel*, GradDip (Lib and Info Mgt) *UniSA*, Library and Information Services Coordinator (concluded 24 December 2020)

Elli-Marie Panagis, BBus (Tourism and Event Mgt) *UniSA*, Events and Projects Coordinator

Virginia Phillips, Events and Projects Coordinator (concluded 30 November 2020)

Jessica Scudds, BCA (Fashion Design and Tech) *Flinders*, Events and Projects Coordinator

Industry Engagement and Application

Peter Godden, BAppSc (Wine Sci) *UniAdel*, Manager – Industry Engagement and Application (concluded 30 June 2021)

Commercial Services

Eric Wilkes, BSc (Hons) (Chem), PhD *UniNewcastle*, Group Manager – Commercial Services

Neil Scrimgeour, BSc (Hons) (App Chem) *Wolverhampton*, Senior Project Scientist

Leanne Hoxey, BSc *UniAdel*, Quality Systems and Laboratory Manager

Randell Taylor, BSc (Hons) *UniAdel*, Manager Trace Laboratory

Alan Little, BSc (Hons) (Biochem), PhD *UniAdel*, Manager Applied Biosciences (started 12 October 2020)

Amy Rinaldo, BBiotech (Hons) *Flinders*, PhD *UniAdel*, Manager Applied Biosciences

Nuredin Habili, BAgSc (Hons), PhD *UniAdel*, Senior Research Scientist

Simon Nordestgaard, BEc, BE (Hons) (Chem), PhD *UniAdel*, Senior Engineer

Bryan Newell, BAppSc (Chem and Physics) *UniSA*, Team Leader – Analytical Laboratory

Pamela Solomon, BTech (Foren and Analyt Chem), BInnovation-Enterprise (Sci and Tech) *Flinders*, Team Leader – Trace Laboratory

Kieran Hirlam, BE (Hons) (Chem), BFin *UniAdel*, Project Engineer

Wen-Hsiang Hsieh, BChemEng *TatungUni*, MChemMatEng *NationalCentralUniTaiwan*, MViticOen *UniAdel*, Project Engineer (started 21 June 2021)

Heather Tosen, BSc *UniAdel*, Scientist

Thomas Almond, BSc (Hons) (Chem) *UniAdel,* Project Technician (concluded 4 February 2021)

Laura Bey, BSc (Foren and Analyt Chem), GradCert (Bus Admin) *Flinders,* Project Technician

Simone Madaras, BSc (Hons) (Foren and Analyt Chem), PhD *Flinders*, Project Technician (started 29 March 2021)

Marco Schoeman, BSc (Biotechnol) *UniAdel*, Project Technician (concluded 18 September 2020)

Ida Batiancila, Laboratory Technician

Zung Do, BFoodSc, MFoodSc *HanoiUniSciTechnol*, PhD *UniAdel*, Laboratory Technician

Kerri Duncan, BSc (Animal Sci) *UniAdel*, Laboratory Technician (started 19 October 2020)

Jesse Hall, BSc (Foren and Analyt Sci) *Flinders,* Laboratory Technician

Thomas Hensel, MSc (Chem) *Flinders*, Laboratory Technician

Kinga Kiziuk, BChem *UniGdansk*, Laboratory Technician (concluded 15 December 2020)

Manreet Bansal, BSc (Nanotech) *Flinders*, Laboratory Technician (started 31 May 2021)

Jacinta McAskill, Cert III (Lab Operations) *Sunraysia TAFE,* Laboratory Technician

Kara Paxton, BPharmSc, BBiomedRes (Hons) *UniSA*, Laboratory Technician

Shaley Paxton, BSc (Nutr and Food Sci) *UniSA*, Laboratory Technician (concluded 24 December 2020)

Dean Smiley, Laboratory Technician

Caitlin Wellman, Cert III (Laboratory Skills) *TAFE SA*, Laboratory Technician (started 18 January 2021)

Matthew Wheal, BSc (Hons) (Biol), PhD *UniAdel*, Laboratory Technician

Qi Wu, BPlantProtection *SouthChinaAgric*, MPlantHealthBiosecurity *UniAdel*, Laboratory Technician

Rachel West, BTech (Foren and Analyt Chem), BSc (Hons) (Foren and Analyt Chem) *Flinders,* Operational Service Technician (started 18 January 2021)

Brigitte Lynch, Dip (Bus Admin) *Careers Australia*, MBA *AustInstBus*, Customer Relations Supervisor

Robyn Gleeson, Customer Service Officer

Jillian Lee, Customer Service Officer

Gina Sellars, Laboratory Assistant

Paul Witt, Courier

Students

Lisa Hartmann, *UniAdel*, PhD student (concluded 31 July 2020)

Jana Hildebrandt, *UniSA*, PhD student

Elise Laporte, *AgroSup Dijon, France,* visiting student (10/3/2020-14/8/2020)

Robin Stegmann, *Technical University of Dresden*, *Germany*, visiting student (16/3/2020-2/8/2020)

Visiting researchers

Jang Eun Lee, *Korea Food Research Institute, South Korea* (5/2/2020-5/2/2021)

Staff activities

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

Anthony Borneman is an Affiliate Associate Professor 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.

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

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

Damian Espinase Nandorfy is a National Science Week SA coordinating committee member.

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.

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 (OIV); 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*.

Mark Krstic is an Adjunct Professor at Macquarie University; Chair of the Australian Wine Industry Technical Conference; member of the Advisory Board for the South Australian Genomics Centre; Director of the National Wine Foundation; member of Hort Innovation's Table Grape Strategic Investment Advisory Panel; member of the Waite Strategic Leadership Group; member of the OENOVITI International Executive Committee; member of Australian Grape & Wine's Sustainability Advisory Committee; Associate Editor of *Wine & Viticulture Journal;* Honorary Senior Fellow at the University of Melbourne; and a graduate of the Australian Wine Industry Future Leaders Program.

Natoiya Lloyd is a member of the Metabolomics Australia Executive Management Group and a committee member of the Analytical and Environmental Chemistry Division for the Royal Australian Chemical Institute.

Mardi Longbottom is a Director of the Australian Society of Viticulture and Oenology; a Director of Australian Grape & Wine; a 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.

Agnieszka Mierczynska-Vasilev is a member of Australian Near Infrared Spectroscopy Group. She is also an Adjunct Senior Lecturer at Flinders University and Adjunct Senior Research Fellow at the University of South Australia.

Bryan Newell is Samples Coordinator for the Interwinery Analysis Group.

Simon Nordestgaard is Conference Program Coordinator for 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.

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.

Tony Robinson is Treasurer and Director of the Australian Society of Viticulture and Oenology; an *ex officio* Councillor of the Royal Agricultural and Horticultural Society of South Australia and a member of the Wine Show Sectional Committee; a member of the Australian Wine Industry Technical Conference Planning Committee; and a graduate of the Australian Wine Industry Future Leaders Program.

Neil Scrimgeour is a member of Australian Grape & Wine's Packaging Committee.

Con Simos is a member of the Australian Wine Industry Technical Conference Planning Committee; a member of the WA Wine Industry Association R&D Committee; and a graduate of the Australian Wine Industry Future Leaders Program.

Cristian Varela is a member of the Editorial Board of the journals *Applied and Environmental Microbiology, International Journal of Food Microbiology, Food Microbiology* and *FEMS Yeast Research*. 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 immediate past chair of the Interwinery Analysis Group committee; Treasurer of the SA branch of the Royal Australian Chemical Institute; a member of the FIVS (International Federation of Wines and Spirits) Scientific and Technical Committee; and Chair of the FIVS working group on fire impacts. He is also a member of the International Wine Technical Summit organising committee.

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 take a scientific approach to provide technical guidance on agrochemical use to meet export market requirements; to preserve the integrity and quality of Australian wine; and to contribute technical expertise to national and international forums on wine regulation.

Staff

Marcel Essling, Prof. Markus Herderich, Anne Lord, Dr Eric Wilkes.

Collaborators

Accolade Wines (Jonathan Breach); Agrochemicals Reference Group; agrochemical manufacturers, suppliers and consultants; Australian Grape & Wine (Tony Battaglene, Damien Griffante, Steve Guy); Australian Pesticides and Veterinary Medicines Authority (APVMA) (James Deller); CropLife Australia (Katie Asplin, Gregory Sekulic); Department of Agriculture, Water and the Environment (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 (Olivier Flandre); Organisation International de la Vigne et du Vin (OIV), France (Pau Roca, Dr Jean-Claude Ruf, Guido Baldeschi); South Australian Research and Development Institute (SARDI) (Dr Suzanne McKay, Dr Mark Sosnowski); Treasury Wine Estates (Dr Kerry DeGaris, Mandy Gerhardy); Wine Institute, USA (Katherine Bedard).

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 to key industry stakeholders. In addition, representation at national and international industry forums raises awareness of matters of concern to the Australian wine industry.

Supporting export of Australian wines

Despite the continuing restrictions on travel, technical support for market access for Australian wine continued, with many forums moving to virtual formats. The project team actively participated in international meetings including the International Wine Technical Summit, FIVS, World Wine Trade Group, the OIV and the APEC Wine Regulatory Forum. Support was also provided to Australian Grape & Wine's Wine Industry Technical Advisory Committee, with information provided on changes to the international regulatory environment and opportunities to improve market access.

Key papers and presentations prepared during the year included:

- A review of the international issues relating to the definition and measurement of sugar in wines provided to the Marlborough Wine Laboratory network in New Zealand
- A presentation on integrating science and law for the Australasian Wine Law Association
- A presentation on the strengths and weakness of various wine fingerprinting technologies to authenticate wine at Australian Grape & Wine's seminar 'Australian Wine: Trade with China and opportunities for diversification'
- A presentation on advances in wine authenticity and provenance testing at the OENOVITI International Symposium 2021
- Recommendations to the OIV on the appropriate use of total dry extract, DL-tartaric acid, certificates of analysis and water additions during winemaking
- A presentation to the International Wine Technical Summit on the importance of proficiency testing programs to ensure ease of trade in international markets
- A paper on the practical measurement of total sulfur dioxide, which was ratified by FIVS and added to their online compendium of technical papers.

The international ring test program managed by the AWRI in conjunction with the Interwinery Analysis Group continued into 2021 after it proved impossible to implement an effective program in 2020 due to the effects of the COVID-19 pandemic. The program is looking to build on its success in aligning the analytical capabilities of a range of APEC nations that import and export wine, and to expand the program to a much wider range of economies.

The project team also supported the formation of a FIVS Scientific and Technical Committee working group on smoke impacts. This group is formulating international industry-based guidance on research priorities, chemical markers for smoke exposure and performance criteria for laboratories offering smoke testing. The group has also commenced an annual program of proficiency testing for laboratories offering smoke testing, which aims to highlight differences in methods and align industry and testing results.

A further major output from the project team, in conjunction with the tracking trends project, was a review of the contribution to overall energy content of different wine components in typical Australian red and white wines. This study, based on a review of data from more than 10,000 wines, demonstrated that the energy content of a wine could be calculated based on measured values for alcohol and sugar, combined with standard typical values for glycerol and organic acids. This approach provides a practical balance between analysis cost and accuracy, and is possible because the variation between wines for glycerol and organic acids was found to be relatively insignificant. The typical contributions of different wine components to overall energy are shown in Figure 1.

The review also found that given the acceptable tolerances in major Australian wine markets it should be possible to use generic values for energy content for most wine styles (based on their sugar content) without having to calculate a value for each individual wine. Results have been presented to the Wine Industry Technical Advisory Committee and will be published in two industry articles in 2021/2022.

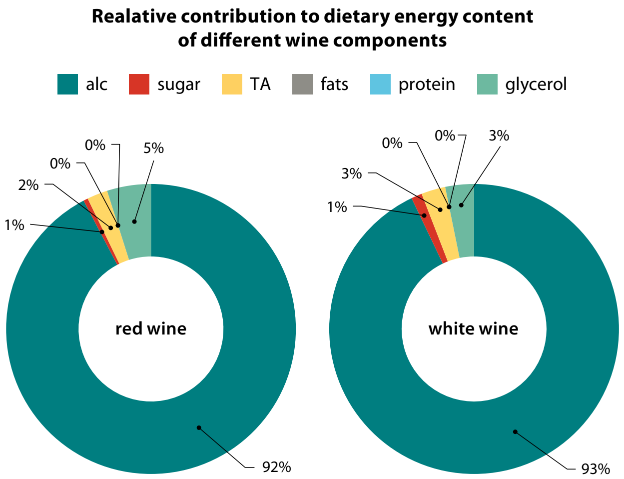


Figure 1. Typical contributions of major wine components to overall energy content for red (left) and white (right) wines (alc: alcohol, TA: titratable acidity)

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 maximum residue limit (MRL) requirements of those chemicals in domestic and key export markets.

Monitoring a changing regulatory environment

In 2020/2021, the project team reviewed 103 Sanitary and Phytosanitary notifications from the World Trade Organization and 29 gazettes issued by the APVMA. These reviews highlighted changes to MRLs for 10 key markets including Brazil, Canada, the European Union, Korea and Japan. During the year there were 44 notifications of MRL changes relevant to wine-grape production, the majority of which were inconsequential because the new MRLs did not require a change to the practices already recommended by the AWRI.

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'). A total of 6,000 copies of the 2021/2022 'Dog book' were produced in June 2021 for distribution in July 2021. 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.

Four new active constituents (eugenol, geraniol, thimol and fluopyram) were registered for use in wine-grape production for the first time. Because the compounds had not previously been used in viticulture in Australia, data on fermentation impacts, sensory effects and residues were required to assess the suitability of these compounds for use in wine production. Decisions about withholding periods to be included in the 'Dog book' were made by the Agrochemical Reference Group.

Following an April 2020 announcement by the European Union about mancozeb that signalled the phasing out of this active constituent, project staff worked with AWRI Commercial Services and Wine Australia to understand the scope of residues from this agrochemical in Australian wine. Seventy-nine wines were provided for analysis by Agrochemical Reference Group members, with data about the timing and number of mancozeb sprays used in their production. A further 21 wines were sourced from AWRI Commercial Services. The wines were analysed for carbon disulfide and ethylene thiourea (possible residues of mancozeb) with the work funded by Wine Australia. In addition, discussions about trials to identify a withholding period and use pattern for mancozeb that does not result in residues in wine were held with an agrochemical producer. The information gained from these activities improved understanding of the residues associated with the use of mancozeb and informed changes to the withholding period recommendations in the 'Dog book'.

In a key achievement during the year, in conjunction with the digital tools project, the databases of agrochemical and MRL information were updated and merged into a single system. This change improved the functionality of the AWRI's online search facility and agrochemical mobile apps, making it possible to perform agrochemical and MRL searches from a single platform. A new version of the agrochemical app was released in June 2021. Information on agrochemicals or pest and disease issues was provided to stakeholders via six *eBulletins,* including one in November 2020 discussing the biosecurity threat posed by fall armyworm and an update on late-season *Botrytis* control options in February 2021.

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

Linda Bevin, Francesca Blefari, Ben Cordingley (from 3 August 2020), Adrian Coulter, Geoff Cowey, Robyn Dixon (from 2 November 2020), Michael Downie (to 24 December 2020), Marcel Essling, Melissa Francis (from 10 January 2021), Peter Godden, Dr Nuredin Habili, Prof. Markus Herderich, Matt Holdstock, Dr Mark Krstic, Dr Mardi Longbottom, Anne Lord, Dr Simon Nordestgaard, Elli-Marie Panagis, Virginia Phillips (to 30 November 2020), Liz Pitcher (from 8 February 2021), Ella Robinson, Jessica Scudds, Con Simos, Randell Taylor, Dr Eric Wilkes.

Collaborators

Accolade Wines (Vanessa Stockdale); Agriculture Victoria (Dr Sze Flett, Megan Hill); Australian Table Grapes Association Inc. (ATGA) (Jeff Scott); Barossa Grape & Wine Association (Nicki Robins); Brown Family Wine Group (Brett McClen); Hoddles Creek Estate (Franco D'Anna); Langhorne Creek Wine Region (Lian Jaensch); Mornington Peninsula Vignerons Association (Olivia Barrie, Tyson Lewis); Mount Langi Ghiran (Damien Sheehan); Murray Valley Winegrowers (Paul Derrico); OICCE Times-Rivista di Enologia, Italy (Dr Giusi Mainardi); Pernod Ricard Winemakers (Kate Lattey); Practical Winery and Vineyard Journal, USA (Don Neel); Riverland Wine (Chris Byrne, Jo Pippos); state and regional wine industry associations; University of Adelaide (Dr Sue Bastian, Dr Christopher Ford); University of Melbourne (Prof. Snow Barlow, Dr Pangzhen Zhang); WBM (Anthony Madigan); Wine Australia (Hannah Bentley, Belinda Bramley, Jo Hargreaves, Anita Poddar, Jacquie van Santen); Wine Communicators of Australia (WCA) (Prue Kline); Wine Network Consulting (Mark O'Callaghan, Rachel Sutcliffe); Wine Victoria (Angie Bradbury, Megan de Jong, Richard Howden, Damien Sheehan, Rachael Sweeney); Winetitles (Sonya Logan, Hans Mick, Samuel Squire); Yarra Valley Wine Growers Association (Caroline Evans); Yalumba Family Winemakers (Luke Wilson).

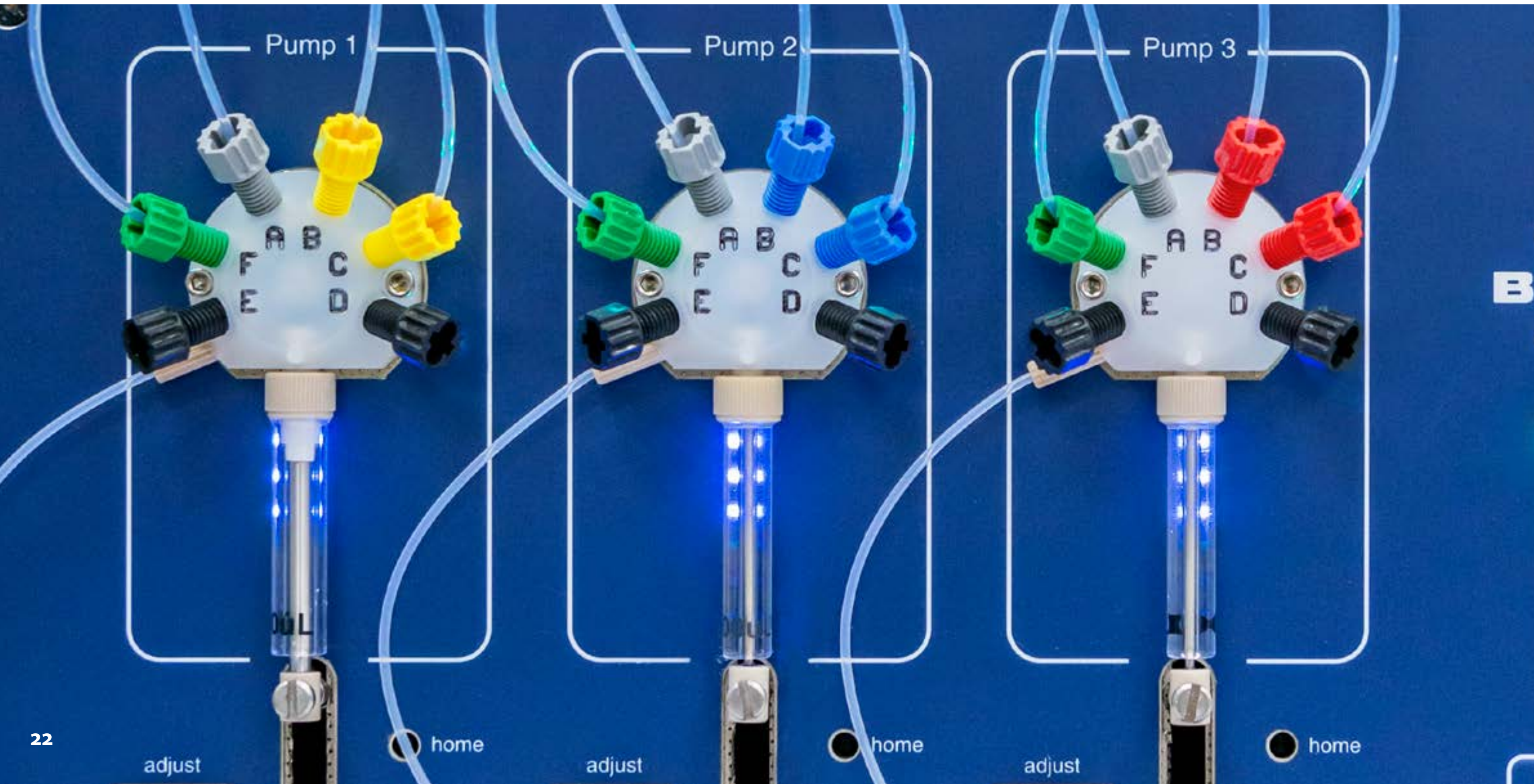
Improving viticulture and oenology practice through extension and education

Background

The AWRI's extension program uses a range of platforms with the aim of facilitating early awareness of research findings, adoption of new technologies and practice change, all of which contribute to improvements in sustainability and competitiveness. Activities include the long-standing AWRI roadshow seminar program; workshops featuring practical components including tastings; webinars; the Research to Practice program; the Advanced Wine Assessment Course; and other tasting events. 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 in the pathway to adoption, as it helps cater for diverse audiences and provides different ways for messages to be delivered. Events delivered by the AWRI in 2020/2021 are summarised in Appendix 2.

Roadshow seminars and workshops

Seven roadshow seminars and eleven workshops were held in 2020/2021 (see Appendix 2 for details). The roadshow seminars presented updates across a range of grape and wine science topics, and the workshops presented Chardonnay winemaking treatment tastings. Of these events, only seven were able to be held face to face, due to COVID-19-related travel restrictions. The other 12 events were held virtually, with new processes and technology for wine sample distribution adopted allowing tasting events to be held successfully online. A total of 337 participants attended seminar and workshop events during the year. While 2020/2021 did not see anywhere near the number of bushfires as the previous year, helpdesk enquiries following a large fast-moving fire in early January in



the Limestone Coast region prompted the organisation of a smoke Q&A session in conjunction with the local regional association, which was delivered in Coonawarra prior to vintage.

Increased focus on practice change

Since the completion of Wine Australia's extension review, the team has increased its focus on activities that facilitate adoption and practice change. Priority areas that are aligned to Wine Australia's Extension and Adoption Strategy 2020-2025 and Strategic Plan are identified in consultation with Wine Australia and Australian Grape & Wine's Research Advisory Committee. This year, two practice change themes were selected: use of oxygen in winemaking; and irrigation scheduling and profitability. A range of activities will be rolled out and delivered in late 2021, vintage 2022 and beyond.

Webinars

Twenty-one webinars were presented to a total of 2,199 attendees in 2020/2021 – a 67% increase in attendance from the previous year (1,316). Webinars covered a wide spectrum of topics including undervine cover crops, irrigation, managing frost, managing *Botrytis*, climate outlooks, use of oxygen during fermentation and new smoke research findings. The portfolio of presenters remained diverse, with more than 50% of the sessions presented by non-AWRI staff. The most popular webinar presented during the year (with 192 attendees) was titled 'The ins and outs of undervine cropping' and was presented by Prof. Tim Cavagnaro, Chris Penfold and Dr Thomas Lines. Views of webinar recordings via YouTube also increased significantly from 19,400 in 2019/2020 to 53,499 in 2020/2021. The webinar recording that attracted the greatest number of views was 'A beginner's guide to grapevine pruning', which has received more than 24,900 views.

Podcast pilot

A pilot program of podcasts was initiated during the year. Three podcast episodes were recorded with AWRI researchers on the topics of Australian Shiraz terroir, 'stone fruit' flavour and the use of oxygen during fermentation, with four additional episodes scheduled for recording early in the new financial year. The podcasts will be released as a flavour-themed series prior to vintage 2022, under the title 'AWRI decanted'.

Educational courses and events

The AWRI delivered three Advanced Wine Assessment Courses (AWACs 51, 52 and 53) in May 2021. A new, completely web-based version of the ShowRunner software platform was used during these events. The events team also coordinated the return of the Barossa Wine Assessment Training, a one-and-a-half-day 'mini AWAC', held in conjunction with the Barossa Grape & Wine Association.

Support for Wine Communicators of Australia

The AWRI provided technical support and hosting of the WCA webinar program 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.

AWRI website

The AWRI website is a major platform for communicating with stakeholders including grape and wine producers, students, potential employees and the general public. More than 177,525 visitors accessed the AWRI website during the year with more than 604,635 page-views. Frequently asked questions in the winemaking resources section were among the top-visited pages. Updates to content during the year included the latest research results on smoke taint (particularly following early-season smoke exposure), restructured information on sustainability and viticulture, new sections on vineyard management practices and brown marmorated stink bug biosecurity, new and updated fact sheets and research updates on projects conducted under the AWRI's *2017-2025 RD&E plan*. 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-two *eBulletins* were delivered to approximately 3,280 subscribers during the year (Table 1). Five issues of the AWRI's electronic newsletter, *eNews*, were distributed to an audience of more than 3,560 subscribers. This publication provides a range of information to AWRI stakeholders, including upcoming events, new information resources and research updates.

Table 1. *eBulletins* issued during 2020/2021

Date	Topic
15/07/2020	Nominations open for AWRI Board positions
29/07/2020	Agrochemical update July 2020
6/08/2020	Reminder: AWRI Board nominations close 14 August 2020
7/08/2020	*Technical Review* August 2020 issue available online
24/08/2020	AWRI Board election 2020 – voting now open
25/08/2020	Eight new AWRI webinars – registration is open now!
26/08/2020	AWRI Board election 2020 – voting clarification
15/09/2020	AWRI Board election result
7/10/2020	*Technical Review* October 2020 issue available online
6/11/2020	Fall armyworm control options
12/11/2020	New agrochemical app and online search facility
24/11/2020	*Bacillus thuringiensis* provides a late-season fall armyworm control option
9/12/2020	*Technical Review* December 2020 issue available online
15/12/2020	Christmas closure and support available during the break
5/02/2021	Late-season *Botrytis*: webinar and key resources
9/02/2021	*Technical Review* February 2021 issue available online
15/02/2021	Managing *Botrytis* in the winery webinar and key resources
7/04/2021	*Technical Review* April 2021 issue available online
10/06/2021	*Technical Review* June 2021 issue available online
15/06/2021	Five new AWRI webinars – registration is open now!
23/06/2021	Agrochemical update – new 'Dog book' available
28/06/2021	New version of winemaking calculators app

Social media and video content

The AWRI's Twitter account reached approximately 3,940 followers, around 100 more than the previous year. The AWRI's Facebook presence grew by more than 370 likes during the year to reach 1,871. The AWRI's YouTube channel offers AWRI webinar recordings and other AWRI video content. The number of subscribers more than doubled from 1,042 in 2019/2020 to 2,442 and the channel attracted more than 123,430 views, up by more than 500% from the previous year, split between 53,499 views of webinar recordings and 69,933 views of demonstration or animated videos.

Much of the increase in YouTube traffic could be attributed to the increased focus on video content that continued during the year, building on the previous year's successful pilot project, with four new videos produced. Three were demonstration videos, covering the topics of protecting vineyards from frost, conducting small-lot fermentations for smoke taint assessments and conducting sensory assessments of potentially smoke-affected wines. The fourth was an animated video, produced in the lead-up to the National Bushfire Conference, to convey the importance of rigorous sensory methods when assessing wines for smoke taint.

Annual report

For the past 66 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 a small number of hard copies. A total of 1,079 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. Four media releases and one joint industry statement with Australian Grape & Wine were prepared and distributed, with 41 media interviews conducted 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 was completed during the year with a new cloud-based data administration portal and search portal. The agrochemical mobile app also underwent a major upgrade with a new MRL search function added.

Redevelopment of winemaking calculators app

The winemaking calculators app is one of the AWRI's most popular tools. It helps winemakers conduct a range of calculations needed during wine production, including conversions, additions and label requirements. A refreshed version of the winemaking calculators app was launched during the year. The updated app includes a new total package oxygen calculator and an improved fining trial calculator.

ShowRunner

Background

ShowRunner is an all-in-one show management software 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 and expanded to support other applications including classification tastings.

Migration to web-based platform

The COVID-19 pandemic resulted in some changes to the longer-term plans for ShowRunner, with the need to bring some activities forward. The planned migration of the existing offline system to a completely web-based platform commenced early, providing ShowRunner clients with a 'lite' version of the software that they could run themselves. For clients requiring the full ShowRunner package, an alternative remote desktop option was provided, which allowed AWRI staff to support the running of the software remotely. The success of these options meant clients could continue to run their events remotely in a cost-effective manner during the COVID-19 pandemic. In total, 19 shows with approximately 6,300 entries were supported in 2020/2021.

BEDA Portal

Development of the BEDA (Benchmark Evaluation Data Analysis) Portal was finalised during the year. Data was consolidated into one database and development activities took place to produce statistical reports for show organisers, judges and exhibitors. Once final testing is completed, the BEDA portal will allow users to perform advanced statistical calculations, develop metrics and benchmark the performance of shows, exhibitors and judges.

Regional engagement – Victorian Viticulture and Wine Innovation Program

Background

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

Events delivered

Key extension activities in 2020/2021 included sustainability workshops and smoke taint seminars with a focus on lessons learned from 2020 and preparedness for future fire events. Additional events covered the ongoing evaluation of a rootstock demonstration trial in the Mornington Peninsula in collaboration with the University of Melbourne; planned burn coordination meetings with the Department of Environment, Land, Water and Planning; and tastings of wines from the AWRI's Chardonnay winemaking treatments trial.

Table 2. Enquiries received by the AWRI helpdesk in 2020/2021

Topic	Number of enquiries
Sustainability	1,077
Winemaking	1,176
Viticulture	178
Total	**2,431**

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, viticulture and sustainability, delivered by an experienced multidisciplinary team.

Helpdesk enquiries

During 2020/2021, 2,431 enquiries were received (Table 2). Of these, 1,354 were wine and viticulture enquiries, significantly less than last year's record number of queries, which resulted from the 2020 bushfire season. Sustainability enquiries continued to grow, almost double the number from last year, and the first year where more than 1,000 enquiries were received (Figure 2). The majority of 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 3 shows that the sources of enquiries were broadly in line with the proportional volume of wine-grape plantings for each state/territory.

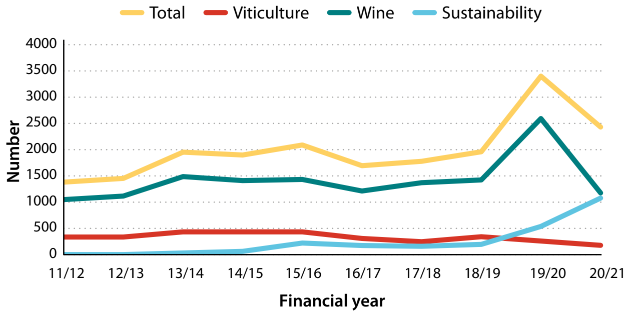


Figure 2. Number of sustainability, viticulture and winemaking enquiries received by the AWRI helpdesk over the past ten financial years

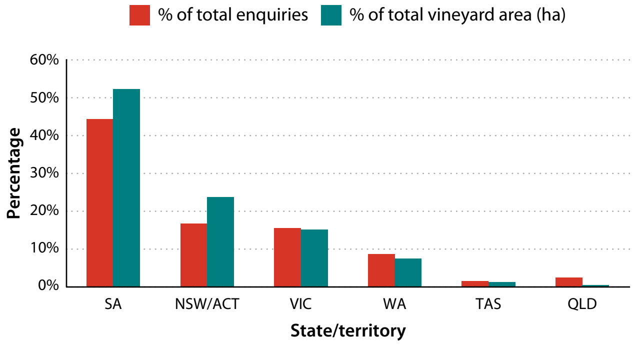


Figure 3. Enquiries received by the AWRI helpdesk in 2020/2021 by state/territory compared to wine-grape vineyard area in 2019 (Wine Australia National Vineyard Scan 2019)

Helpdesk enquiries are now grouped using 20 subject keywords. The number of enquiries received under each keyword is compared to historical monthly data 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 4 shows the wine and viticulture enquiries from 2020/2021 arranged in order from most to least used keyword, highlighting key events or issues of interest during the year.

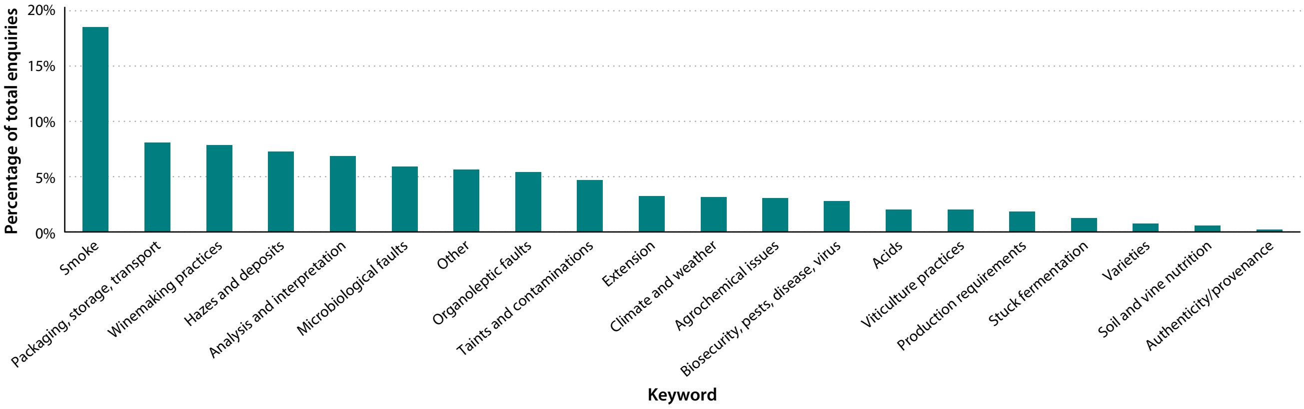


Figure 4. Winemaking and viticulture enquiries received by the AWRI helpdesk in 2020/2021, organised by keywords. Enquiry numbers are represented as a percentage of total national wine and viticulture enquiries, where the total number was 1,354.

Sustainability enquiries

During the year, the sustainability team responded to 1,077 enquiries primarily from grape and wine producers, as well as state and regional associations and international enquirers. A high proportion of sustainability enquiries were received during the Sustainable Winegrowing Australia renewal period between July and August.

Viticulture enquiries

During the year, the viticulture team responded to 178 enquiries. The main topic of concern for growers was a La Niña event that occurred during the 2020/2021 growing season and the associated impacts from a wetter season. The AWRI held a webinar early in the season with Dr Paul Petrie from SARDI comparing the forecast La Niña event with previous events. There was concern that demand for fungicides registered for downy mildew might exceed supply and contingencies were prepared to deal with this, but in the end these were not required. *Botrytis* outbreaks were reported across regions in Victoria and NSW, and the AWRI later issued two *eBulletins* and held two further webinars on management of late-season *Botrytis* in the vineyard and winery. Overall, however, the helpdesk did not observe an increase in queries regarding increased disease pressure in vineyards or an increase in *Botrytis*-affected wines.

The pest insect fall armyworm, *Spodoptera frugiperda,* was first detected in northern Queensland in January 2020 and later in NSW in November 2020. This highly invasive pest has the potential to feed on grapevines but its behaviour is not well understood. Chemical controls were made available via Australian Pesticides and Veterinary Medicines Authority permits but were not required. Two *eBulletins* were produced to communicate to industry about this new pest, including options for its control.

Winemaking enquiries

Thanks to the cooler season, there were fewer extreme temperature days and a generally lower risk of bushfires – a welcome relief after the 2020 season. Despite this, the largest number of enquiries received by the helpdesk were on smoke taint, with fires occurring in the Adelaide Hills and the Limestone Coast, along with smaller spot or grass fires in the Barossa Valley and McLaren Vale, SA and Wooroloo in the Swan District, WA. A forecast wetter winter for 2021 raised the potential of a shorter window of opportunity to conduct prescribed or planned burns to reduce bushfire risk. Several states therefore brought forward the start of their burns to early March, which caused concerns from neighbouring wine regions with fruit still on the vine. The AWRI worked with state and regional bodies to provide accurate information on controlled burns and their impact on viticulture, to support communications with organisations conducting burns. A large number of queries on smoke taint answered by the helpdesk stemmed from wineries processing 2020 wines and investigations of 'smoky' sensory characters developing in wine over time in bottle. Some smoke-affected wines are being tasted and analysed for smoke compounds by the helpdesk team every three months to examine the impact of bottle age on smoke-affected wines.

Fewer heatwaves and an extended growing season also saw fewer stuck fermentations and associated problems, possibly because producers had both time and tank capacity to manage ferments appropriately rather than being challenged by vintage compression. Higher acidity levels (in many cases double the usual concentrations of malic acid) were reported, resulting in high initial titratable acidities in must and subsequent larger than expected pH increases post-malolactic fermentation.

One-third of the 'packaging, storage and transport' queries related to the use of sulfur dioxide (SO_2), with queries covering appropriate concentrations for microbiological control, particularly for *Brettanomyces* yeast; typical losses of SO_2 over time during bottle maturation or wine ageing; SO_2 removal following over-additions during vintage; and SO_2 bleaching of young red wines. Queries also covered the potential quality impacts of wine being held up in transit to China due to trade disputes. An increase in helpdesk queries categorised under 'winemaking practices' related to wineries seeking information on techniques such as carbonic maceration, skin contact, water addition, fortification, sweetening, use of dried grapes in ferments, fining, aeration of red ferments, and nutrient management and requirements of ferments. A new 'winemaking practices' section was added to the AWRI website to provide information on these types of topics.

Winemaking problem-solving investigations

This year only 11% of winemaking enquiries resulted in investigations, where samples are requested and analysis performed to identify the problem and recommend a solution, a lower proportion than the longer-term average of 20%. The helpdesk team conducted 152 problem-solving investigations on 1,270 samples (Table 3). This was approximately 50 fewer investigations than most years; however, the number of samples submitted was higher than usual. This increase was due to higher numbers of investigations of quality variation, pressure and gushing in sparkling wines; microbiological variation in bottled stock; potential *Brettanomyces* contamination from a vineyard; and smoke development or indole degradation in bottle over time. As for enquiries, use of the problem-solving investigative service was mostly in line with the proportional volume of wine-grape plantings for each state or territory, with slightly more investigations conducted for Victorian producers than in previous years (Figure 5).

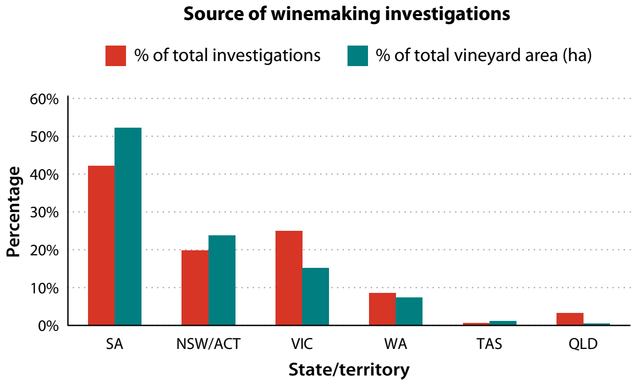


Figure 5. Winemaking investigations undertaken by the AWRI helpdesk in 2020/2021 by state/territory, compared to wine-grape area in 2019 (Wine Australia National Vineyard Scan 2019)

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

Table 3. Winemaking investigations conducted and samples analysed by the AWRI helpdesk in 2020/2021

Type of investigation	2020/2021
Hazes and deposits	41
Microbiological issues	27
Sensory investigations	16
Taints and contaminations	44
Other investigative analyses	23
Closure-related investigations	1
Total number of investigations	**152**
Total number of samples analysed	**1,270**

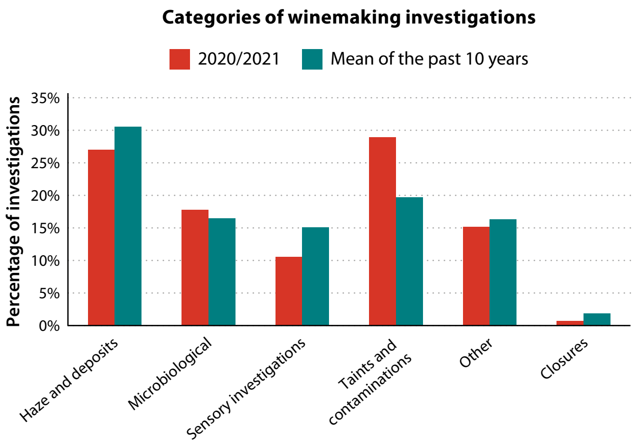


Figure 6. Distribution of winemaking investigations across five main categories (plus closures). For 2020/2021 the total number of investigations was 152.

Hazes and deposits

Haze and deposit investigations were nearly equally split between heat and cold instabilities. In addition, there were several deposits in packaged wine where the material was likely remnants of a biofilm that had become non-viable and had absorbed phenolic material from wine. Biofilms are extracellular polymeric substances secreted by microbes. The polymers are made up of polysaccharides, proteins, nucleic acids and lipids. These substances allow biofilms to adhere to surfaces, making them harder to remove with general cleaning. They can reside in dead spaces of bottling lines, hoses, pumps, valves or under seals and become dislodged upon occasion. The AWRI website includes a series of pages on cleaning and sanitation practices in the winery, in barrels and during packaging.

Microbiological issues

Some wineries reported higher acetic acid production in some white ferments this vintage. Investigations highlighted possibly elevated loads of microorganisms or *Botrytis* on fruit which may not have been obvious by visual assessment. Another investigation worked with a winery and vineyard to re-examine if *Brettanomyces* could be sourced from the vineyard. The company reported that one small parcel of a vineyard had consistently produced *Brettanomyces* in wine made in tank over seven years, whereas the surrounding vineyards had not. Throughout this investigation, no *Brettanomyces* yeast could be detected across different sections of the vineyard, in wine made at the winery or in wine made off-site at the AWRI under conditions favourable to *Brettanomyces* growth. These results are consistent with earlier studies suggesting that the vineyard is not a primary source of *Brettanomyces* in wine.

Sensory investigations

Sensory issues investigated by the helpdesk are often related to either oxidation or sulfide development. This year sensory investigation numbers decreased by about half of last year's figure (Figure 7); however, the number of taint investigations increased by a similar amount (Figure 8). Of the sensory investigations, sulfide-related faults were predominant and indole formation in sparkling wine continued to be a concern. An indole degradation trial conducted by the helpdesk team saw a sparkling wine with 114 µg/L of indole (threshold 23 µg/L) degrade to 7 µg/L only after 18 months of bottle ageing.

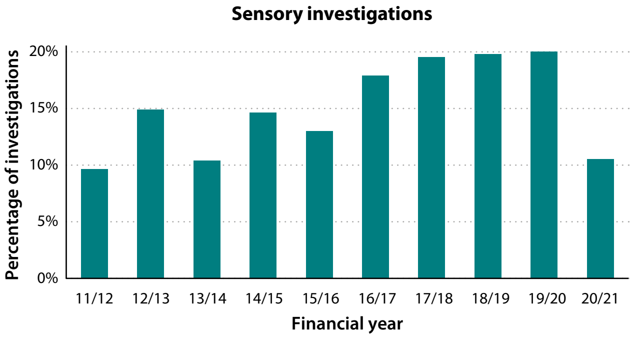


Figure 7. Sensory-related investigations conducted by the AWRI helpdesk from 2011/2012 to 2020/2021

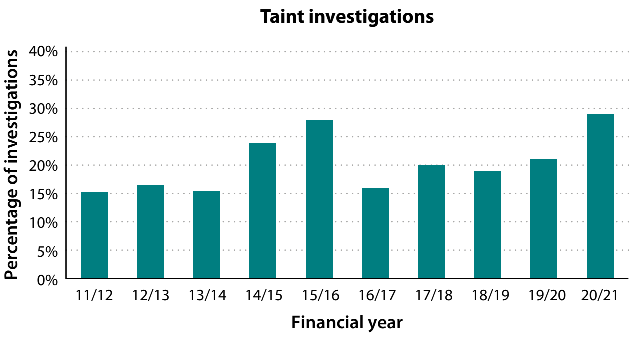


Figure 8. Taint-related investigations conducted by the AWRI helpdesk from 2011/2012 to 2020/2021

Taints and contaminations

Taints and contamination queries during the year covered topics including:

- brine leaks, hydraulic oil contaminations and burnt pump stators during vintage
- contaminations caused by using non-standard wine vessels or equipment
- contamination of winemaking materials and facilities during the mouse plague across NSW and Victoria
- a herbaceous 'green' flavour (2-isopropyl-3-methoxypyrazine) caused by ladybirds in several batches of wine across two regions (possibly related to the cooler season).

Taints and contamination investigations included:

- comparisons of smoke analytical results with the sensory perception of 'smoky' characters as assessed by the AWRI quality panel
- batches of wine reported to be affected by a 'musty' taint resulting from a batch of tainted dry ice. In conjunction with the flavour team, helpdesk staff confirmed the 'musty' taint was not any of the typical bromo- or chloroanisoles in the existing analysis suite. GC-MS analysis confirmed the taint compound of interest was also not any previously reported compound known to cause 'musty' taints in wine. Further analysis resolved the taint compound of interest, but additional work is needed to concentrate and identify it.
- a product cross-contaminated by bisabolol, a sesquiterpene compound, which has a 'sweet', 'floral' aroma. Bisabolol is a common ingredient in cosmetic and other personal care products, as well as tea, but is not naturally present in wine.
- wines affected by tainted sterile filters, tainted cross-flow filtration equipment, tainted water and chlorine-based cleaning agents.

Other investigations

A number of investigations examined gushing or excessive spritz levels in white and red wines sealed with both screwcap and natural cork closures and in sparkling wine. Causes of spritz in table wines included elevated pressures being used at bottling; increased dissolved carbon dioxide concentrations; overfills and increased pressures following heating during transport; and refermentation. Gushing issues in sparkling wine were predominantly due to either inadequate riddling or cold instability issues. An article on gushing was written to provide further information to industry.

Fermentation and level sensor trials

Trials were performed on a range of in-tank fermentation and level sensors at a commercial winemaking scale. This included pressure transducers, radar, hydrogen sulfide and oxygen reduction potential probes. Trials were mainly performed on white ferments, with some initial experiments also performed on red ferments. Differential pressure measurement effectively tracked both ferment density and tank levels during white ferments and during wine storage. Radar also allowed effective level measurement but was more complex to fit to tanks if levels were to be measured up into the neck without impeding access.

Low-flow commercial bubbler-type pressure-based systems also effectively tracked ferment density. Red ferments were more challenging than white ferments because of the presence of skins, particularly early in ferments before the skins had risen. Significant advances were made on designing screens for these devices for use in red ferments to make them more practical.

Library services

Background

The John Fornachon Memorial Library holds one of the largest collections of grape and wine resources in the world, with more than 80,000 print and digital resources on offer via a range of information discovery tools and services. The library supports the Australian grape and wine sector by providing access to technical information that assists learning, understanding and adoption of research outcomes.

eBook collection

The library's eBook collection is steadily growing with almost 230 titles. Usage rate is high relative to the number of eBooks in the collection, with 9,774 activities (downloads, online views or pages printed) recorded this year.

Staff publications database

The staff publications database, accessible via the AWRI website, holds more than 2,230 AWRI-authored articles. This year, the database received nearly 6,818 hits, an increase in website traffic of 17.5%. A number of these publications are offered via open access direct to the full-text articles where licensing allows. For non-open access articles, a total of 832 staff publications were requested and delivered under copyright declarations.

Online information packs

Online information packs are reference lists with a specific topic focus which provide growers and winemakers with seamless access to highly curated and relevant information. The number of requests for resources from information packs increased by more than 30% to 299 and the library delivered a total of 1,271 articles (213 more than the previous year). A new information pack on glycosides was added to the AWRI website during the year.

Library reference and information requests

The library responded to a total of 1,059 reference and information requests, resulting in supply of 2,474 articles (Table 4). The number of articles requested from the current literature presented in *Technical Review* increased by 137 this year to 1,079. Library staff also performed 30 specialised literature searches on a variety of topics across winemaking, vineyard management, winery operations and pest management.

Table 4. Articles supplied from library collections in 2020/2021

Article type	Number of items supplied
AWRI staff publications	832
Technical Review collection	1,079
Library reprint collection	563
Total	**2,474**

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 (to 13 August 2020), Sheridan Barter, Dr Marlize Bekker, Dr Jenny Bellon, Laura Bey, Eleanor Bilogrevic, Dr Keren Bindon, Dr Anthony Borneman, Ben Cordingley (from 3 August 2020), Dr Peter Costello, Kate Cuijvers, Dr Julie Culbert, Simon Dillon, Damian Espinase Nandorfy, Angus Forgan, Assoc. Prof. Leigh Francis, Dr Toni Garcia Cordente, Dr Richard Gawel, Peter Godden, Yevgeniya Grebneva, Laura Hale (from 27 January 2021), Dr Yoji Hayasaka (to 10 July 2020), Prof. Markus Herderich, Kieran Hirlam, Dr Josh Hixson, WenWen Jiang, Charlotte Jordans, Dr Alicia Jouin, Jelena Jovanovic, Stella Kassara, Radka Kolouchova, Dr Mark Krstic, Renata Kucera (from 16 November 2020), Allie Kulcsar, Dr Darek Kutyna, Desireé Likos, Jane McCarthy, Dr Agnieszka Mierczynska-Vasilev, Dr Cristobal Onetto, Elli-Marie Panagis, Dr Mango Parker, Dr Wes Pearson, Lisa Pisaniello, Song (Luke) Qi, Tim Reilly, June Robinson, Jessica Scudds, Dr Simon Schmidt, Alex Schulkin, Neil Scrimgeour, Dr Tracey Siebert, Con Simos, Mark Solomon, Dr Cristian Varela, Flynn Watson, Dr Eric Wilkes, Dr Patricia Williamson.

Students

Stephanie Angela (University of Adelaide), Jana Hildebrandt (University of South Australia), Eva (Yihe) Sui (University of Adelaide), Colleen Szeto (University of Adelaide).

Visiting students

Elise Laporte (AgroSup Dijon, France, to 14 August 2020), Robin Stegmann (Technical University of Dresden, Germany, to 2 August 2020).

Collaborators

Accolade Wines (Warren Birchmore, Gavin Blacker, Ella Hoban, Samantha Scarratt, Preet Sidhu, Nigel Sneyd); Adelaide Hills Wines (Jurie Germishuys, Darren Golding, Mark Kozned, Dylan Lee, Peter Leske, Ben Schmaal, Simon Tolley, Martha Valkenburg, Tim Wicks); Agriculture Victoria (Joanne Bui, Dr Tim Plozza, Pei Zhang); Australian Grape & Wine (Anna Hooper); Australian National University, Eccles Institute of Neuroscience (Prof. John Bekkers); Ball Corporation, USA (Brent Trela); Belvidere Winery (Sam Dunlevy); Best Bottlers (Mark Zeppel); Brown Family Wine Group (Geoff Alexander, Joel Tilbrook); Constellation Wines, USA (Martin Di Salvo, Chris Hartless, John Thorngate); Coriole Wines (Duncan Lloyd, Mark Lloyd); Cornell University, USA (Prof. Gavin Sacks); CSIRO (Dr Paul Boss, Dr Rob Bramley, Dr Fabienne Reisen, Dr Charlotte Williams); Deakin University, CASS Food Research Centre (Prof. Russell Keast, Assoc. Prof. Robert Shellie); Department of Primary Industries NSW (Darren Fahey); E. & J. Gallo Winery, USA (Dr Gal Kreitman, Steve Tallman); Flavourtech (Paul Ahn); Flinders University (Assoc. Prof. Martin Johnston, James Tsoukalas); Grain Producers SA (Caroline Rhodes); Hochschule Geisenheim University, Germany (Prof. Doris Rauhut, Prof. Manfred Stoll); Indonesian Institute of Sciences, Indonesia (Dr Satriyo Wahono); Iowa State University, USA (Erin Norton); Dr John Danilewicz, UK; Katnook Estate (Natalie Cleghorn, Dan McNicol); La Trobe University (Prof. Ian Porter); Max Planck Institute for Polymer Research, Germany (Prof. Hans-Jürgen Butt, Dr Kaloian Koynov); Mount Langi Ghiran (Damien Sheehan); National Wine and Grape Industry Centre (NWGIC), Charles Sturt University (Dr John Blackman, Dr Andrew Clark, Dr Sijing Li, Prof. Leigh Schmidtke); Northwest Agriculture and Forestry University, China (Dr Anque Guo); NSW Wine Industry Association (Angus Barnes, Mark Bourne, Liz Riley); Orora Beverage (Kane Chandler); Pernod Ricard Winemakers (Philip Deverell, Kate Lattey, Dr Jean Macintyre); PIRSA (Bodhi Edwards); QUT (Prof. Kirill Alexandrov); SA Grain Industry Trust (Dr Allan Mayfield); SARDI (Dr Marcos Bonada, Dr Paul Petrie); Sofia University, Bulgaria (Dr Aleksey Vasilev); Stellenbosch University, South Africa (Prof. Wessel Du Toit); Tolley Viticulture (Simon Tolley); Treasury Wine Estates (Iain Jones, Josh Miles); University of Adelaide (Assoc. Prof. Sue Bastian, Prof. Timothy Cavagnaro, Assoc. Prof. Cassandra Collins, Dr Lukas Danner, Dr Robert Falconer, Assoc. Prof. Paul Grbin, Assoc. Prof. David Jeffery, Dr Richard Muhlack, 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 South Australia (Dr Miguel de Barros Lopes, Prof. Krasimir Vasilev); VA Filtration/Memstar (David Wollan); Vinpac International (Greg Edwards); Wine Victoria (Rachael Sweeney); Wines by Geoff Hardy (Shane Harris); Yalumba Family Winemakers (Heather Fraser, Brooke Howell, Glynn Muster, Louisa Rose).

Identification and control of compounds responsible for important sensory attributes

Background

The aroma and flavour properties of wine 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 less time-consuming sensory methods for wine evaluation, to better link wine composition and sensory outcomes.

Foliar nutrient sprays and changes in varietal thiols

The influence of foliar sprays on the concentration of potent 'tropical fruit' thiol compounds in grapes and wine has been studied over several seasons. Chardonnay wines made from an experiment with a sulfur and urea-containing spray formulation applied in a Barossa Valley vineyard in the 2019/2020 season showed a strong increase in 'passionfruit', 'green grass' and 'box hedge' sensory attributes and in thiol compound concentration, even when only a single spray pass was applied. The wines showed less 'banana'/'confectionery', 'stone fruit' and 'floral' characters than the wines made from unsprayed vines (Figure 9). As part of this study, grapes were also harvested from rows that had been sprayed in the previous season. The wines made from this treatment were found to be not significantly different from the untreated control, showing that the foliar spray did not cause a carry-over effect in the following year.

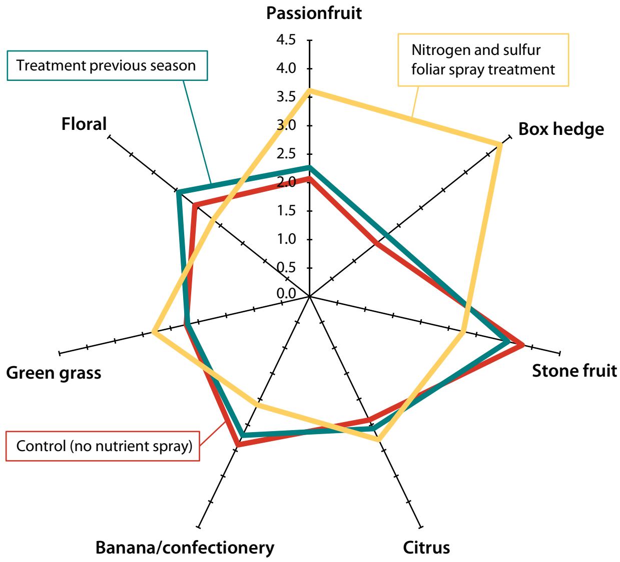


Figure 9. Mean aroma attribute ratings for unoaked wines made from Chardonnay vines treated close to veraison with a nitrogen and sulfur foliar spray application, compared to untreated vines and also vines sprayed in the previous season

In 2020/2021 a study was completed with Adelaide Hills Chardonnay fruit, combining the effects of the spray protocol with the use of high and low thiol-producing yeast strains. In addition, trials were undertaken with industry partners to assess foliar sprays under commercial vineyard practice conditions, in Chardonnay and Sauvignon Blanc vineyards in Padthaway. Feedback on the effects on wine flavour and the practicality of the spray regime has been positive.

'Apricot' flavour in white wine

To investigate the previously identified link between grape-derived monoterpene compounds and 'apricot' aroma in white wines, free and glycosidically bound monoterpenes were measured in berries of two clones of Viognier (Entav 1042 and Montpellier 1968) sampled from sun-exposed and canopy-shaded positions at two sites (one warmer [Riverland] and one cooler [Eden Valley]). Of the five free monoterpenes measured, geraniol was found at the highest concentration for each sample (59 to 148 µg/kg). Similar levels of total free monoterpenes were found for all the Eden Valley samples and for Riverland/Entav/sun-exposed grapes (220-280 µg/kg). However, when comparing the site/clone/exposure pairs, 33 to 50% lower concentrations of total free monoterpenes were found in canopy-shaded grapes than sun-exposed grapes in both clones at the Riverland site. For the bound monoterpenes, monoterpene polyglycosides were the most prevalent, with a 1.3 to 2.0-fold higher concentration found in the sun-exposed grapes for each of the four site/clone/exposure pairs. No difference was seen for geraniol glucoside between any site/clone/exposure pair. Overall, the effect of sun exposure in increasing grape monoterpenes in Viognier grapes was more evident in the Riverland than in Eden Valley. This might have been due to the more substantial canopy on the Riverland vines and/or the later ripening and harvest of Eden Valley fruit during heatwave conditions.

'Raisin'/'jammy' flavour in ripe Shiraz

The volatile compounds that cause overripe 'port-like' or 'dried fruit'/'jammy' aroma in red wines, and especially in Shiraz, are not well characterised. Sensory assessment of late-harvest Shiraz grape berries from a Barossa Valley vineyard showed an increase in 'dried fruit' and 'jammy'/'cooked fruit' attributes compared to the commercial harvest timepoint. Gas chromatography-olfactometry analysis (with human assessors acting as 'detectors') was completed and showed key odorants (specifically short-chain aldehydes and ketones and longer chain diketones) were present in grapes that had experienced extended hang-time, or were more shrivelled. Based on these key odorants, analytical methods were developed, including a specialised chemical ionisation procedure. These were used to quantify compounds in grape and wine samples with overripe characters to confirm their importance.

Interactions of volatile compounds with taste and mouthfeel compounds in red wine flavour

The experience of drinking and enjoying a wine arises from the combined input from the senses: sight, smell, taste and touch. While little studied, non-volatile compounds such as tannins and amino acids can interact with volatile aroma compounds to give rise to an integrated perception of desirable wine flavour. The abundant amino acid, proline, was shown in previous studies to be involved in 'fruit sweetness', playing a role in enhancing perceived viscosity and fruit flavour.

An existing HPLC analytical method used for quantification of amino acids was complemented with a newly developed rapid nuclear magnetic resonance (NMR) method requiring little sample preparation or instrument time, developed in conjunction with Metabolomics SA. A range of commercially produced red wines were analysed for amino acid concentration and subjected to sensory assessment. In line with recent data from another sample set, some amino acid levels were found be surprisingly high, well above their reported taste thresholds. Interestingly, inland warm climate Cabernet Sauvignon wines had some of the highest concentrations.

To investigate the interactive effects of amino acids with volatiles, colour and tannin, a statistically designed blending study was initiated, involving two lots of Riverland Cabernet Sauvignon wines, with higher and lower amino acids respectively, and an alternative variety red wine with low amino acids but high colour, flavour and tannin. The wines were blended according to a ternary design, and the effect of the different components will be examined to determine optimal levels of flavour and mouthfeel attributes and the relationships with wine composition.

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 is caused by the action of enzymes from salivary bacteria. The glycosides can also release flavour compounds during winemaking and bottle ageing. Previous work showed that there is a wide range of sensory responses to glycosides among individuals, with some easily able to perceive strong flavour from all types of glycosides, some only able to perceive flavour from some glycoside compounds, and others who report only a weak taste or do not respond at all. Glycosides have been shown to contribute 'fruity' flavour, and are also well known to be involved in smoke taint.

Understanding glycoside flavour precursors

Storage trials of grape marc-derived extracts rich in monoterpene glycosides showed a strong dependence of the observed flavour evolution on the original source of the extracts. For example, grape marc from Muscat varieties yielded extracts that were highly potent and led to the evolution of significant quantities of 'floral' monoterpenes in Chardonnay wines after six months of storage. As such, accessing grape marc from aggregated sources of numerous varieties (e.g. from processing facilities) may not be ideal for the potency of the resulting extracts.

The rate of release of monoterpenes from glycosides was also characterised, partly to assist in future accelerated ageing studies to better predict outcomes following bottle storage. First-order rate curves provided a means to determine reaction half-lives for the breakdown of geraniol glucoside, and were related to the monoterpene composition in wines.

In-mouth release of 'tropical fruit' thiols

Sauvignon Blanc juices with known concentrations of amino acid-bound thiol precursors were extracted to yield a thiol precursor-rich extract. The extract was added to water and model wine and subjected to sensory evaluation for in-mouth release potential. Initial results did not look promising in establishing an in-mouth flavour contribution for thiol precursors, with only weak flavour evident in the water solutions approximately 30 seconds after tasting.

Molecular drivers of wine texture and taste

Background

High-quality wines 'feel' right. An important element of wine quality for consumers is the general perception of how the wine feels in the mouth when consumed. As such, wine texture is a major product differentiator for wine. Improving wine texture relevant to the desired style of wine depends on knowing the compounds that influence wine texture and understanding their winemaking origins. This knowledge will enable winemakers to optimise positive textural attributes while minimising negative ones.

Understanding the drivers of negative wine characters

Formation of the bitter/'hard' tasting compound tryptophol sulfonate was investigated post-bottling in Chardonnay, Riesling and Gewurztraminer wines, and its concentration was found to stabilise after approximately nine months. The results further confirmed that wine SO_2 concentration during bottle storage (50 vs 150 mg/L) was a significant driver of tryptophol sulfonate formation. Threshold testing revealed a heterogeneous distribution across tasters, with only around 1 in 10 tasters being able to taste tryptophol sulfonate at the concentrations found in the white wines at 18 months post-bottling. Subsequent formal sensory analysis of the white wines using an unscreened panel found no significant differences in bitterness among the white wines with different tryptophol sulfonate concentrations.

A follow-up study was conducted with Shiraz fruit fermented using the same high tryptophol-producing yeast as the white wine study and adjusted to two SO_2 concentrations (40 and 110 mg/L) and two pH values (3.4 and 3.7) prior to bottling. The study showed that as for the white wines, little tryptophol sulfonate was formed during winemaking, but in contrast to the white wine study, the compound did not increase in the red wines post-bottling, regardless of SO_2 concentration or pH. This is most likely due to binding of SO_2 by red wine components.

Proteinaceous fining agents were previously found to be ineffective in removing tryptophol sulfonate from wine, so as an alternative, the potential for increased concentrations of wine polysaccharides to mitigate the bitter sensory impact of tryptophol sulfonate was explored. Such an increase of polysaccharide concentration in wine can be achieved by the addition of commercial polysaccharide additives or by fermentation on solids or by yeast lees contact. To test this possibility, isothermal calorimetry was used to explore interactions between tryptophol sulfonate and three polysaccharide fractions taken from white wine – a high molecular weight mannoprotein fraction, a small molecular weight fraction containing rhamnogalacturonans, and a medium molecular weight polysaccharide fraction containing arabinogalactan proteins and low molecular weight mannoproteins. The medium molecular weight polysaccharide fraction is known to affect taste and perception of hotness. The results of the trial suggested that tryptophol sulfonate did not bind with these polysaccharides at the concentrations found in wine. The difficulty of removing tryptophol sulfonate from wine once it has formed suggests that prevention strategies, including selection of low tryptophol-producing yeast, and/or judicious application of SO_2 pre-bottling should be employed to manage its formation.

Discovery of a potentially new bitter compound in white wine

Phenolic fractions were isolated from a bitter-tasting white wine prepared from hard pressings. A non-targeted metabolomics approach was used to analyse the composition of these fractions and identify compounds that correlated with their perceived bitterness. A hexose ester of coumaric acid was identified as a suspected bitterant. The molecule was synthesised, and the synthesis process scaled up to produce sufficient quantities for sensory assessment, with its identity and purity validated by NMR. A tasting of the compound in model wine by experienced assessors indicated that it was a potential bitterant. Subject to further sensory assessment, the preparative-scale synthesis methodology will be applied to produce similar compounds of the same class for further bitterness assessment.

Towards an understanding of 'savoury' character in wine

The term 'savoury' is synonymous with complex, high-quality wines. While the molecular drivers of 'savoury' character in wine are uncertain, the amino acid glutamic acid, succinic acid, and sodium and potassium salts are likely to contribute to 'savouriness' in wine either directly or most likely by interaction. The concentration ranges of these compounds (Figure 10) were determined based on a survey of Australian and international wines, and the information gained will be incorporated into future sensory experimental plans.

Impact of dissolved CO_2 in still wines

Still wines contain sub-saturated concentrations of carbon dioxide (CO_2) which are modified by winemakers prior to bottling to achieve a desired level, depending on wine type and style. Previous sensory investigations on the interactions of dissolved carbon dioxide (DCO_2) with the wine matrix in still wine showed that DCO_2 predominantly contributes to wine texture by adding a 'spritz' character. To further explore the perception of DCO_2, a model mouth system that mimicked the hydrophilicity of mouth surfaces was developed to determine CO_2 ingress through different thicknesses of human saliva. Thicker salivary layers were more effective in reducing CO_2 ingress when DCO_2 levels were high (1.5 g/L). At CO_2 concentrations more typical of still red and white table wine (0.375 g/L) salivary layer thickness did not influence CO_2 ingress, suggesting that individual differences in CO_2 perception would be more pronounced in wines that are semi-sparkling/'spritzy' than in still table wines.

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 extraction and subsequent impact on various aspects of wine stability, clarity and filterability. The research seeks to find improved ways to measure wine macromolecules and their interactions, to better understand the impacts of winemaking techniques, additives or surfaces (e.g. filtration membranes, adsorbents) on the colour, cold stability and heat stability of wine. The results generated will provide winemakers with options to better predict and manage macromolecule extraction, stability and loss, ultimately with the aim of improving production efficiency.

New insights on how composition affects cold instability differently for red and white wines

The management of potassium tartrate (KHT) instability in wine is critical, as the presence of KHT crystals in packaged wine can be perceived by consumers as a wine fault. Traditional cold stabilisation represents one of the most expensive aspects of the winemaking process, due to the energy use and time required for cooling, as well as the potential for wine volume loss. Besides developing alternative methods for cold stabilisation, it is also important to understand the compositional factors which lead to KHT instability. A comprehensive survey of red and white wine composition and cold instability was conducted over two seasons, in order to identify wine compositional factors which may contribute to cold instability. For unfined white wines,

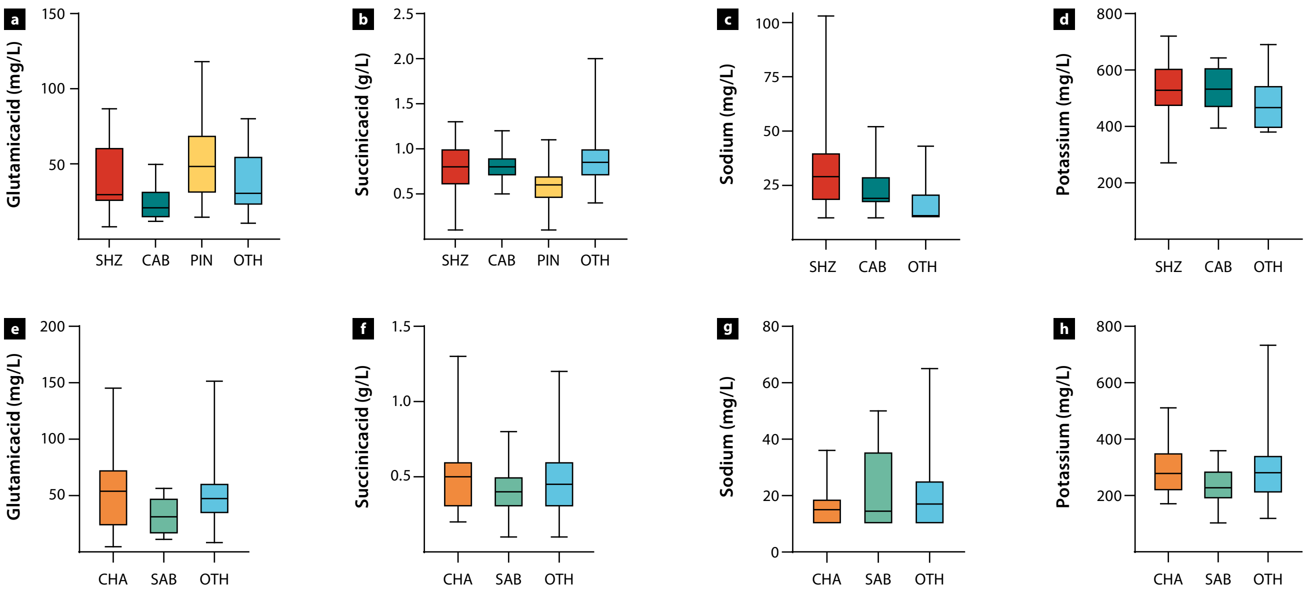


Figure 10. Concentration ranges of compounds associated with 'savoury' character in wine by variety, based on a survey of 200 Australian and 17 international wines for glutamic and succinic acids and 135 Australian and 15 international wines for sodium and potassium. The boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured (SHZ – Shiraz, CAB – Cabernet Sauvignon, PIN – Pinot Noir, CHA – Chardonnay, SAB – Sauvignon Blanc, OTH – other).

it was found that lower concentrations of wine tartaric acid and high potassium largely explained KHT crystal formation, and this was not clearly influenced by macromolecules such as polysaccharides, proteins and phenolics. A follow-up study used purified fractions of the principal macromolecules in white wine, combining them within the range of concentrations expected in wine. Protein and phenolics (flavonoids and hydroxycinnamic acids) were found to slightly reduce KHT crystal formation either independently or in combination (Figure 11A). White wine polysaccharides had no impact on KHT crystal formation, contrary to expectation (Figure 11B). The inhibition of KHT crystallisation by phenolics was removed when polysaccharide was present. However when protein was combined at higher concentrations with polysaccharide, a small drop in KHT crystal formation was found, but not to the extent found for protein alone. These results demonstrate why in white wine, which invariably has a substantial concentration of polysaccharides, the potentially protective influence of other macromolecules has little to no influence on KHT crystallisation.

A corresponding experiment with unfined red wines over two seasons produced some interesting results. Higher tannin concentrations were invariably associated with increased cold instability, and the ratio of tartaric acid to potassium was not important. As for white wines, polysaccharides were found not to be an important inhibiting factor in KHT crystallisation in red wines, which was unexpected. Wine colour, total anthocyanin and polymeric pigments were significant in the models developed, but depending upon the season had a variable relationship with cold stability.

Further investigation was conducted of the key red wine macromolecule categories (tannin, anthocyanin and polysaccharide) and their interactions for the range of concentrations expected in red wine. Contrary to what was expected from the wine compositional survey, tannin was found to introduce some protection against KHT crystallisation when applied in the higher concentration range (Figure 11C). Red wine polysaccharides, which are present at higher

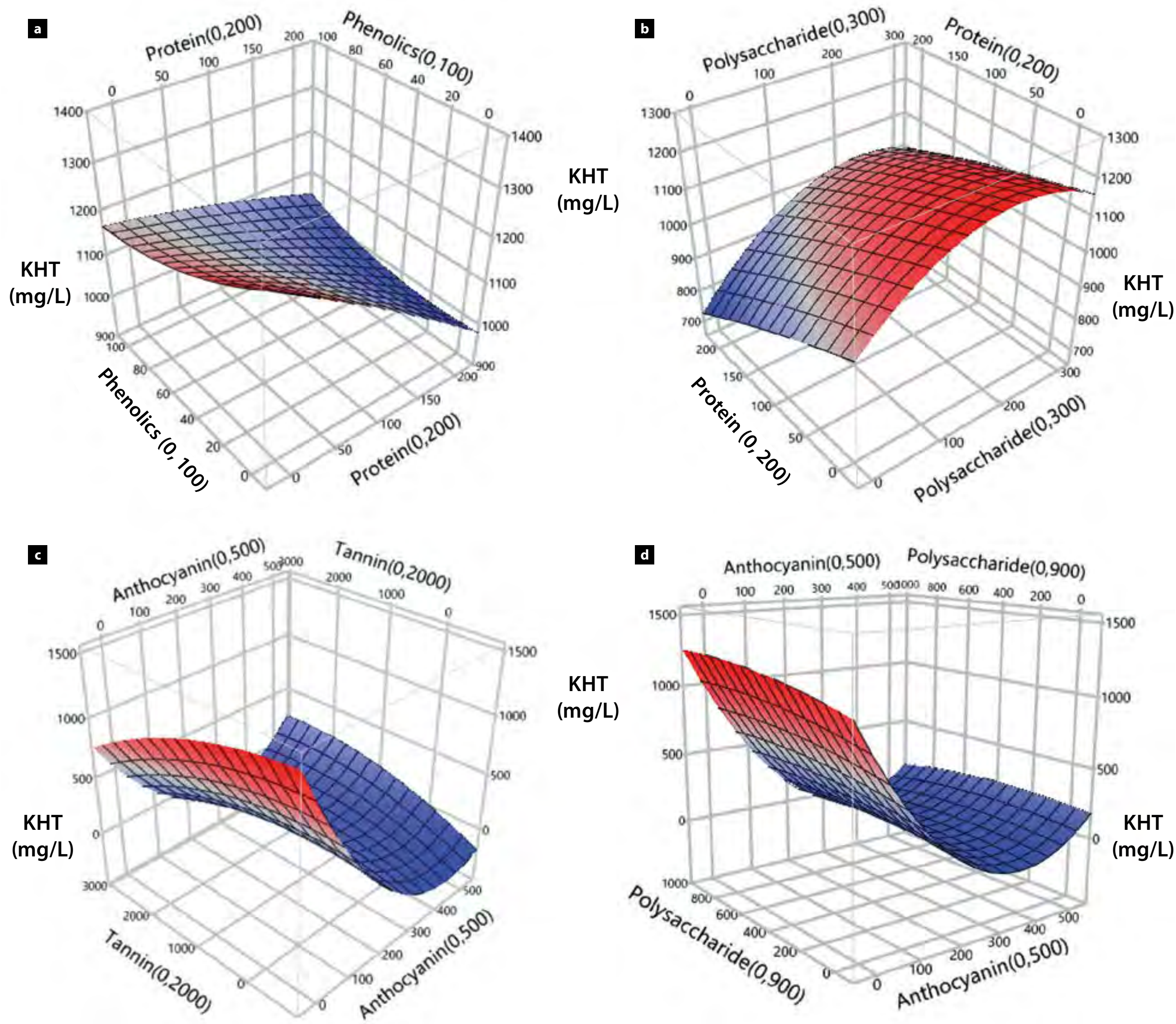


Figure 11. Three-dimensional plots where the surface shows the change in potassium bitartrate (KHT) crystal formation in model wine during a three-day cold test, as the ratio of macromolecules changes (where 1,100 mg/L is highly unstable becoming stable as the value approaches 20 mg/L). (a) model white wine, protein and phenolics; (b) model white wine, protein and polysaccharide; (c) model red wine, tannin and anthocyanins; (d) model red wine, polysaccharide and anthocyanin.

concentrations in red wines than in white, also showed no protective effect against KHT crystallisation. Red wine polysaccharides also reduced the inhibiting effect of tannin on crystal formation when in combination. Surprisingly, anthocyanin was found to bring the model wine close to cold stability, at the lowest applied concentration, and this effect was exerted even when tannin or polysaccharide were present (Figure 11C and D). It was found that the addition of anthocyanin to a bentonite-fined white wine or model wine was able to cold stabilise the wine to the same extent as a commercial dose of potassium polyaspartate. Although the potential role of anthocyanin in limiting KHT instability has long been known, these results potentially explain why the compositional study revealed a positive association between wine tannin and KHT crystal formation. Wines with higher tannin concentration may more rapidly undergo polymerisation reactions with anthocyanin, losing the protective monomeric structural forms. This suggests that the measurement of anthocyanin, and its expected conversion (and hence loss) to other forms over time, may provide a useful prediction of the likelihood of cold instabilities developing during red wine maturation.

Rapid detection of haze-forming proteins in white wine by fluorescence sensing technology

The heat test is the industry standard for measuring the propensity for haze proteins in wine to develop heat instability over time; however, it is time-consuming and often not sufficiently accurate. The lack of accuracy may lead to over-fining with bentonite, which might strip wine phenolics and aroma compounds, or under-fining, which increases the risk of protein instability. This problem was addressed by developing an efficient and selective fluorescence-based sensing technology to detect haze-forming proteins in white wine. The newly developed method is simple, provides rapid results, and is accurate, being selective for haze-forming proteins, providing a linear detection range and a low detection limit of 2 mg/L. The usefulness of the technology was validated using a wide range of white wines. To confirm the accuracy of the protein concentration determined with the fluorescent dye, the protein concentration in the wines was also measured by HPLC. A linear regression of results was prepared for all wines studied, with an excellent R^2 value (Figure 12), indicating that the amount of total protein calculated using the dye closely approximated the amount measured by HPLC (which quantifies both thaumatin-like and chitinase proteins individually). In addition, using the fluorescent dye method, a baseline protein level below which haze in white wine did not occur was found to be 12 mg/L for this diverse sample set. Given that certain wines may be heat stable at substantially higher protein concentrations, the protein detection approach cannot immediately replace the heat test, as it presents a risk of over-fining if extremely low protein levels are targeted. Instead, it is suggested that rapid protein detection could be used as an initial screen to determine if the protein concentration is above the threshold for instability and, after that, the heat test could be used to predict protein stability only on those samples above the threshold.

Can accelerated maceration improve the extraction of phenolics in red winemaking?

Coriole in McLaren Vale has recently implemented Della Toffola's maceration accelerator (DTMA) as one of its winemaking tools. This maceration technique was developed for low-phenolic varieties such as Pinot Noir, and aims to gently cut the skins of the grape berry, facilitating the extraction of tannin and colour, without damaging the seeds. It has also been trialled on other grape varieties such as Shiraz, with some success (Kang et al. 2020). An AWRI collaboration with Coriole aimed to compare changes in 'phenolic potential' (an assessment of both total and extractable tannin, anthocyanin and phenolics) of its Shiraz vineyards during ripening. It was found that extractable tannin and colour increased during ripening for all vineyards, while total tannin decreased gradually, and then remained constant (Figure 13). From this assessment, two vineyards designated 'high phenolic potential' and 'low phenolic potential' were selected. The grapes from these two vineyards were harvested at commercial ripeness and underwent either standard crushing or DTMA. The maceration times were also varied, with either a short maceration (four days) or a standard maceration (seven days). For wines prepared from the low phenolic potential vineyard, DTMA maceration was very effective at increasing phenolic extraction. This was evident for both tannin and colour (Figure 13), even after four days of maceration. For the high phenolic potential vineyard, however, DTMA did not affect phenolic extraction and the DTMA-treated low phenolic potential wines had an equivalent tannin concentration to the high phenolic potential wines, and a higher colour after seven days of maceration. For both vineyards, DTMA did not change the composition or size of the tannin, confirming previous reports that tannin is not selectively extracted from damaged seeds. It was interesting to find that for the low phenolic potential vineyard, DTMA increased the extraction of grape pectins into the wine (result not shown), but these were unaffected for the high phenolic vineyard. This may indicate that grapes with high phenolic potential could also have relatively degraded and porous skins which facilitate the extraction of both tannin and pectins. For the low phenolic potential vineyard, the use of DTMA may have increased skin breakage, facilitating the release of otherwise non-extractable tannin and polysaccharide from the grapes during maceration. The work has shown that DTMA is a relatively gentle maceration technique, which winemakers could use to improve phenolic extraction from low-phenolic fruit.

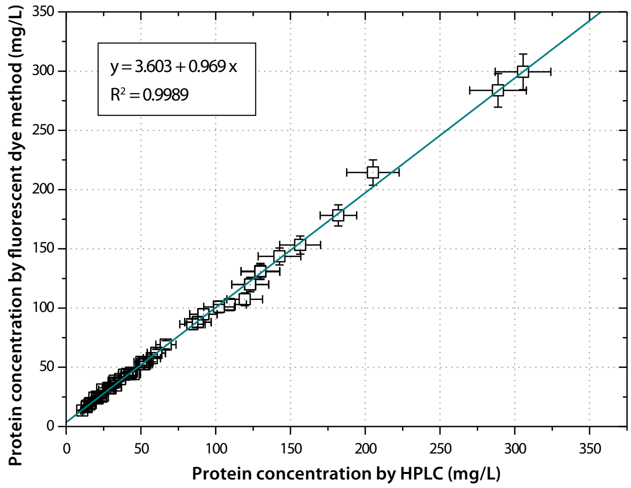


Figure 12. A comparison of protein concentrations determined using the fluorescent dye method and by HPLC, showing an excellent correlation between the two methods ($R^2 = 0.9989$)

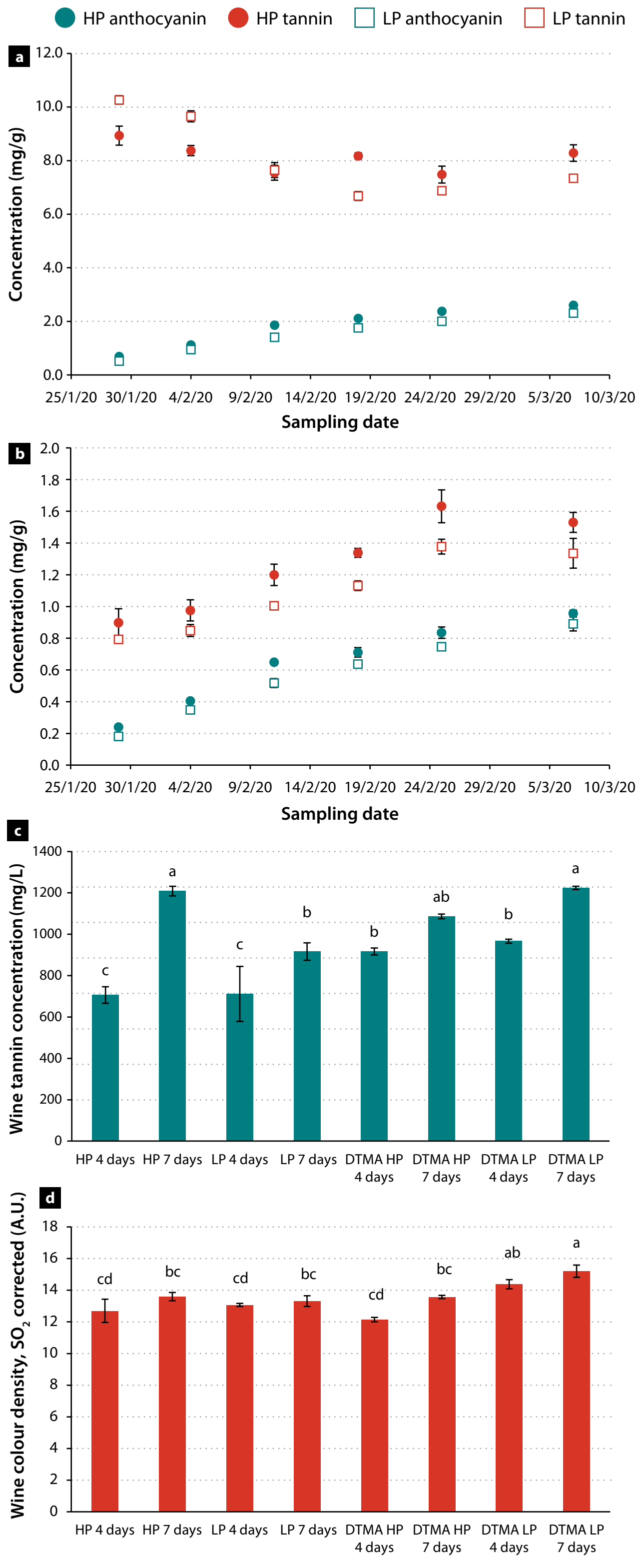


Figure 13. Tannin and colour measures determined for grapes and wines prepared from high phenolic potential (HP) and low phenolic potential (LP) vineyards, with or without accelerated maceration (DTMA) and with a four- or seven-day maceration period. (a) Total grape tannin and anthocyanin from the two vineyards during ripening; (b) Extractable grape tannin and anthocyanin from the two vineyards during ripening; (c) Tannin concentration in wines made from the two vineyards; (d) Corrected colour density in wines made from the two vineyards. (Data are the mean ± standard error compared by one-way ANOVA, P<0.05, different letters indicate significant differences by Student's post-hoc T-test).

Digging deeper into how aeration during red winemaking affects phenolics

Oxygen plays an important role in wine quality, and is known to improve red fruit attributes, decrease astringency and decrease reductive odours (Day et al. 2021). It is thought that oxygen can accelerate the transformation of the wine phenolic matrix, effectively ageing the wine more rapidly. Indeed, aeration during red wine fermentation has been found to affect both the structure of wine tannin and its reactivity with salivary proteins, potentially affecting wine astringency or bitterness. To further the AWRI's work on oxygen and phenolics, a new study was initiated with two main aims. Firstly, a fractionation protocol was adapted to isolate discrete classes of phenolics in red wine (Figure 14), in order to identify impacts of oxygen on phenolic composition using mass spectrometry. This was applied to Shiraz wines which had undergone different levels of aeration during fermentation, from reductive (control) through to high oxygen (HiOx). The second objective was to characterise the potential interaction of the different phenolic fractions with proteins in saliva, using polyproline as a model salivary protein. A binding affinity study was performed using isothermal titration calorimetry (ITC). The result for the fraction containing polymeric material including tannins and pigmented polymers (Fraction 5) is included in Figure 14. Comparing the ITC results for the control and HiOx treatments, a very different binding pattern with polyproline was found. Contrary to what was expected, Fraction 5 from the control wine did not bind to polyproline (data not shown). However, ITC of the same fraction prepared from the HiOx treatment indicated binding events had occurred. The binding was found to be a low entropy binding with a secondary weak association. Hydrophobic linkages were also detected between Fraction 5 and polyproline. Work is continuing to understand the response of each of the fractions using ITC, and to further characterise their composition with mass spectrometry. Generally, the results suggest that oxygen can bring about structural changes to phenolic polymers that directly affect tannin-protein interactions, potentially influencing both their stability (solubility) in wine and perceptions of wine texture (e.g. astringency or bitterness).

Harnessing ultrafiltration technology to manage wine phenolics

Ultrafiltration is one of a number of membrane filtration techniques available to the wine industry. It differs from the more widely used cross-flow microfiltration in that the semi-permeable membranes used have a far lower pore size (5-20 nm). The power of this technique is that it is able to remove or concentrate macromolecules of interest in the permeate or retentate respectively, including proteins, polysaccharides and phenolics. Ultrafiltration has recently been applied with some success to improve the heat stability of white wine by removing haze-forming proteins (Sui et al. 2021) and in the process was shown to also remove phenolics. To follow on from this work, a new project was initiated by the University of Adelaide, applying ultrafiltration towards the recovery of valuable phenolic end-products from red wines, or to ameliorate phenolic faults in heavy-pressed or laccase-affected white wines. In a preliminary benchtop trial on a commercial red wine, spiral ultrafiltration membranes of nominal molecular weight cut-offs 10 kDa, 20 kDa and 75 kDa were used, aiming to achieve a permeation degree between 50 and 95%. While ultrafiltration had a negligible effect on wine alcohol and pH, all tannin and polysaccharide were sequestered in the retentate, irrespective of the pore size of the membrane or the permeation degree. Anthocyanin was also strongly retained by the ultrafiltration process, in particular for the 10 kDa membrane, producing a concentrated retentate with an intense colour. Since phenolics such as tannin and anthocyanin are in fact far smaller than the nominal molecular weight cut-off of the membranes, this points to interactions (including fouling) at the membrane surface preventing permeation. Future work will continue to investigate the fouling phenomenon as well as the potential application of ultrafiltration to modulate phenolics in commercial winemaking, with a stronger focus on white wine production.

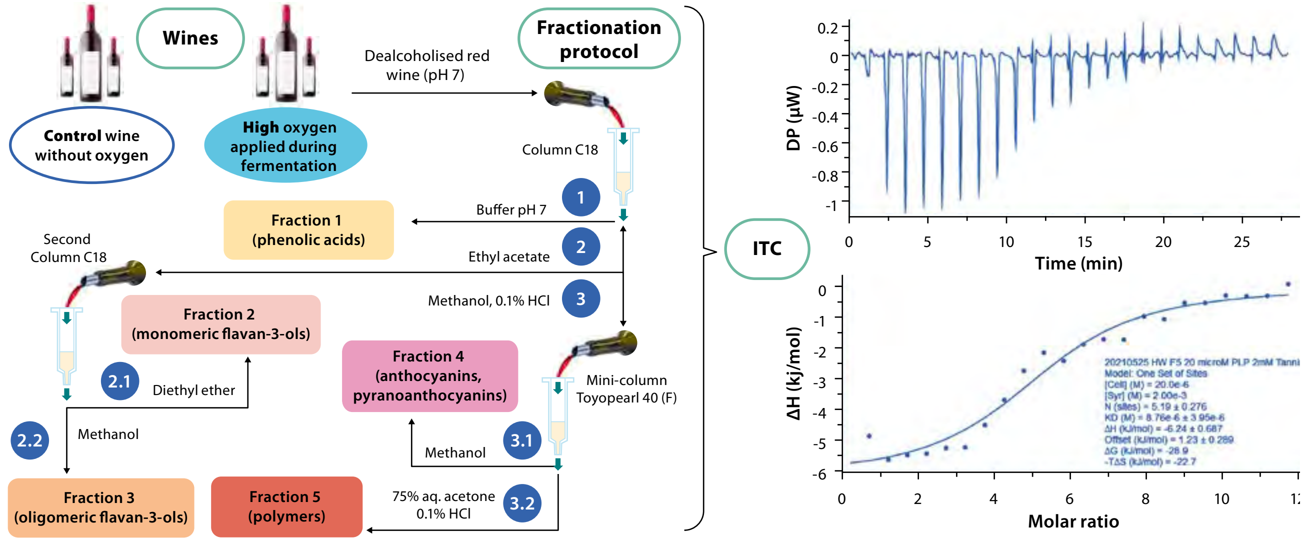


Figure 14. Schematic of the winemaking treatments and fractionation protocol followed to obtain five discrete phenolics fractions, showcasing the data obtained using isothermal titration calorimetry (ITC) for the titration of Fraction 5 (high oxygen treatment, HiOx) with polyproline as a model salivary protein

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

Background

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

Aeration of wild ferments – a window on whites

The motivation for using aeration as a fermentation management tool may vary for those conducting non-inoculated fermentations, and the practice may also introduce new opportunities. Modulating the timing of aeration provides a chance to interact with microbial community members other than *Saccharomyces cerevisiae,* which can be dominant during the early phases of fermentation. Earlier work showed that long-duration, low-intensity aeration of non-inoculated white ferments decreased ferment duration, similar to the effect in inoculated ferments. Ferment duration decreased irrespective of when aeration was applied within the first three days. However, aeration at 72 hours after grape crush resulted in the biggest decrease in fermentation duration. Analysis of microbial community structure revealed that earlier aerations benefitted specific genera within the ferment, most notably *Hanseniaspora* and *Torulaspora*. However, species-level changes, as have been observed following SO_2 addition (Cuijvers et al. 2020), were not observed following aeration. Overall the wines' chemical composition was minimally affected by aeration; nonetheless, the wine produced without aeration was more similar to wine produced with later aeration than earlier aeration. The similarity of later aeration to non-aerated ferments is presumably because the benefits of later aeration accrue more to *S. cerevisiae* than the non-*Saccharomyces* genera.

If a little aeration soon after grape crush helps promote the persistence of non-*Saccharomyces* genera and reduces fermentation time, is more aeration better? The idea that more aeration is better for non-inoculated white ferments was put to the test by aerating ferments with increasing intensity for 24 hours after grape crush. The effect of aeration on fermentation progress was similar to that observed in the previous year; however, marked changes in the volatile profile of the wines were observed, particularly for the higher intensity treatments. Higher intensity aeration stimulated increases in volatile acidity and promoted the production of higher alcohols. Analysis of microbial community composition again showed that early aeration stimulated the growth of several non-*Saccharomyces* species, particularly *Hanseniaspora* and *Torulaspora*, but that increasing the aeration intensity did not result in higher cell numbers for those populations. At the highest aeration intensities, decreases in the *S. cerevisiae* population size were observed. This work has shown that aeration can be used successfully to reduce fermentation times in non-inoculated fermentations. However, it is possible to aerate white ferments excessively, with excess volatile acidity the result (Varela et al. 2021).

If aeration can reduce fermentation times in white ferments, what about reds?

This year the project team completed an analysis of four years of pilot-scale vintage trials evaluating the effect of aeration on Shiraz ferments. This work provides a comprehensive overview of what to expect when aerating a red ferment (Day et al. 2021). Crucially, it shows that the aeration of a red ferment is unlikely to decrease fermentation time. If there is no stimulation of fermentation performance, why should a winemaker aerate their red ferments? The answer lies in the ability of aeration to promote 'red fruit' characters in red wines and suppress 'reductive' characters and astringency. The study also showed that the changes to wine style associated with aeration could be achieved without adverse effects on malolactic fermentation, whether conducted simultaneously or sequentially.

The promotion of 'red fruit' characters was strongly related to increases in the concentration of ethyl-2 and ethyl-3-methylbutanoate (abbreviated as Et2MeBut and Et3MeBut in Figure 15) across the entire series of trials. Aeration's suppression of 'reductive' characters was related to low molecular weight sulfur compound concentrations, a previously described relationship (Bekker et al. 2021). Finally, the work also highlighted the general resilience of red fermentations to aeration. Unlike white ferments, red ferments exposed to high-intensity aerations did not suffer the same detrimental effects of volatile acidity. In examples where elevated volatile acidity was measured analytically, it was not perceived by the sensory panel that evaluated the wines.

In summary, although the boost to fermentation performance may not be the same in red as in white fermentations, the reasons for using aeration are still compelling. In red ferments, aeration becomes a tool for shaping wine style instead of managing fermentation performance.

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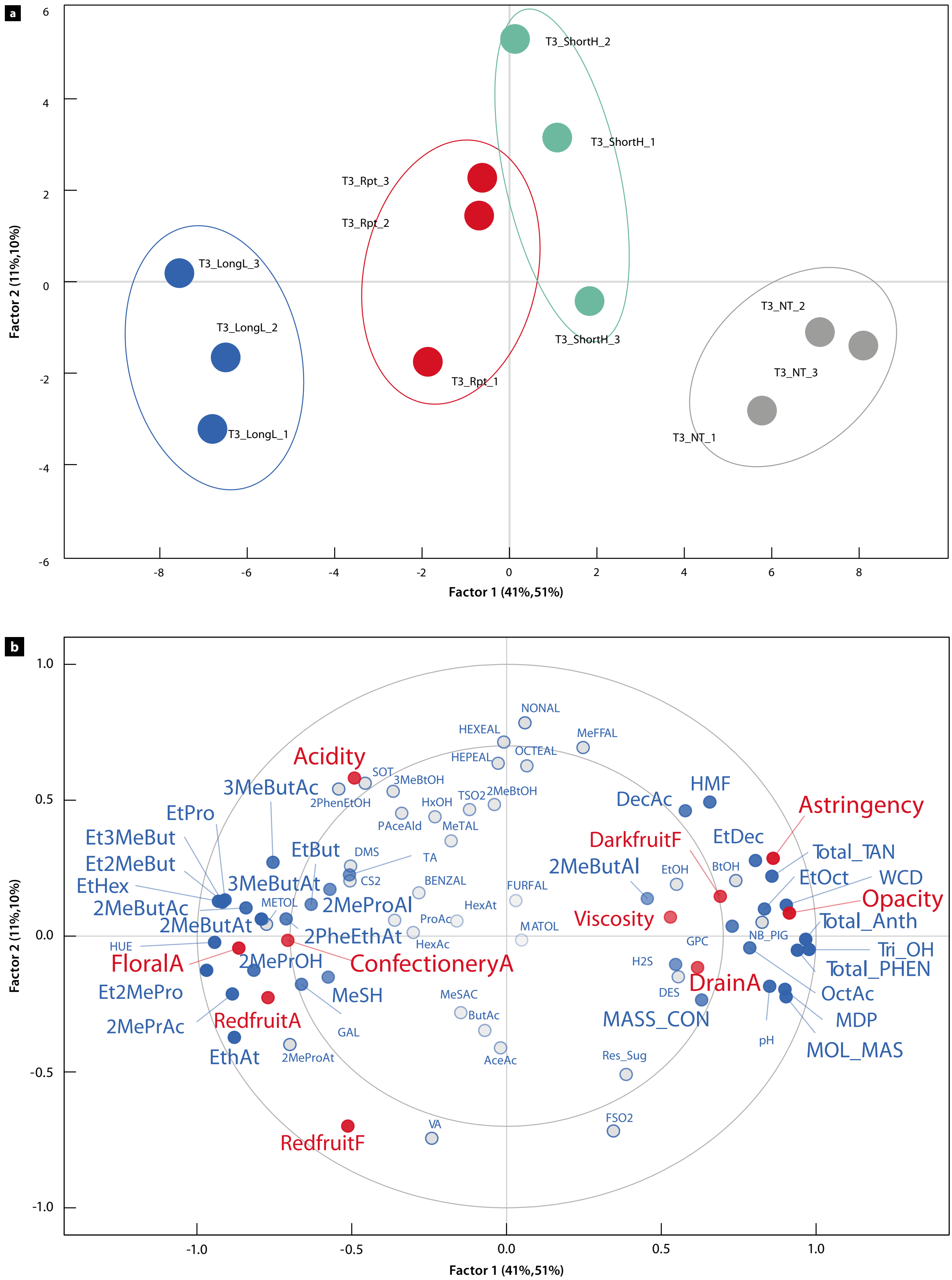

Figure 15. Factors 1 and 2 from the scores (a) and loadings (b) plots from partial least squares (PLS) regression from a trial of aeration duration during fermentation of Shiraz. Treatments in panel (a) refer to the length of aeration and are indicated by ShortH (2 hours), LongL (24 hours), Rpt (4 x 1 hour), NT (no treatment). Compounds significant to the PLS model are indicated in panel (b) by filled blue circles; sensory attributes are indicated by filled red circles. This figure is modified from Day et.al (2021) with permission from the publisher.

Low- and no-alcohol wine products: understanding technical and sensory-related challenges and opportunities

Background

This project seeks to define the desirable sensory attributes of existing low- and no-alcohol wines or other beverages in the market and use this information to support development of wine-like beverages that can satisfy consumers' demands. The project will also evaluate the production practices, technologies and ingredients required to give low- and no-alcohol products the palate attributes found in full-bodied dry wine.

Industry reference group

An industry reference group was formed from a diverse range of stakeholders along the supply chain. The group was engaged to evaluate sector interest in no- and low-alcohol wine products and to help establish relevant researchable questions. This group will continue to be involved with this project as it moves forward.

Sensory analysis of commercially available products

Preliminary sensory evaluations were completed on more than 90 low- and no-alcohol products available in Australia, including sparkling, white and red wine products, beer, cider and spirits. From these products, a subset were selected based on a range of sensory properties and quality designations. These products were subjected to more rigorous sensory evaluations: quantitative descriptive analysis and the Pivot©profile rapid sensory method. Results highlighted the wide range of sensory attributes associated with these products, while also showing the attributes perceived as most 'wine-like'. These products will also undergo comprehensive chemical analysis, which, when evaluated with the sensory profiles, should offer insight into production methods and characteristics that are best suited to these products.

Alcohol removal technology

Various methods for the removal of alcohol were evaluated through communication with producers as well as review of existing literature. Methods such as spinning cone column (SCC), reverse osmosis (RO), vacuum distillation, nanofiltration, freeze concentration, evaporation and extraction with organic or supercritical solvents, and resin adsorption are all options for removing alcohol from wine. However, only SCC and RO technologies are commonly used in the wine industry. Spinning cone column tends to be the preferred choice for the production of wines with an alcohol content of < 0.5% v/v while RO dealcoholisation tends to be used for low-alcohol products > 5% v/v.

Putting microbial diversity to work in shaping wine style

Background

While many wine yeasts are currently available for winemaking, extensive genetic analysis has shown the genetic diversity among these yeasts to be extremely shallow. This limited depth means there is 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-H_2S and low-acetate-producing yeasts. Together these breeding and selection strategies deliver non-genetically modified germplasm for winemakers seeking a point of differentiation in their wines.

Hybrid yeast – when one plus one equals three

Interspecific hybridisation is the term used when two different species are mated together. It is a process that the project team has used to introduce genetic diversity into traditional wine yeasts and to harness the traits in more distantly related yeasts – traits that can then be used in winemaking. While the blending of genomes often results in additive combinations of characteristics, occasionally a hybrid may exhibit characteristics different from either parent. One such strain, a hybrid between *Saccharomyces cerevisiae* and *Saccharomyces uvarum*, displays robust fermentation properties in high-sugar juices while producing wines with lower concentrations of acetic acid than either parent.

The team set about discovering the genetic basis of the 'low acetic acid' trait in the *uvarum* hybrid. The genome of the hybrid was picked apart by sporulating it to generate hundreds of progeny. Through the process of sporulation, each spore not only receives half of the genetic material from the parent, but the genetic material that it does receive is re-assorted, meaning that no two spores are identical. As a result, it is possible to associate physical characteristics with genetic features. The genetic elements contributing to the 'low acetic acid' trait of the hybrid were determined by sequencing each spore and defining its acetic acid production potential. This work pointed toward the loss, or retention, of a specific *S. uvarum* chromosome being a defining feature in the hybrid, responsible for the strain's ability to produce a minimal concentration of acetic acid. The chromosome's involvement in the hybrid strain's acetic acid phenotype was demonstrated by removing the entire chromosome from the original hybrid strain and showing that the 'low acetic acid' trait was lost. This work shows that a yeast strain can be more than just a simple sum of its parts.

The *S. uvarum* hybrid discussed above is just one of seven hybrids that have been produced by hybridising a single robust *S. cerevisiae* strain with each of seven different members of the *Saccharomyces* clade. How these different hybrid strains ferment red grapes and contribute to red wine's compositional and sensory qualities was assessed in a vintage trial in 2020, with the wines undergoing sensory descriptive analysis this year (Figure 16). The wines differed across nine descriptive attributes. Key among the more positive attributes were aromas of 'cherry', 'red berry', 'baking spice' and 'vanilla'. However, some strains produced wines with more prominent 'boiled egg' and 'canned vegetable' aromas. This work has identified hybrid strains that appear well suited to the production of red wine.

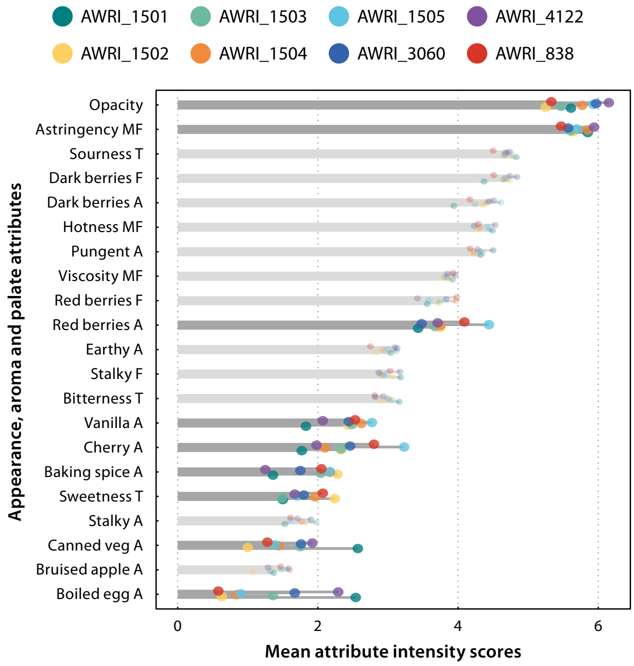

Figure 16. Mean attribute intensity scores for sensory attributes assessed in Shiraz wines made with seven different interspecific hybrids and a *Saccharomyces cerevisiae* parent (yeast strain indicated by different colour dots). Attributes for which there was evidence for difference among the treatments are indicated by larger and more strongly coloured dots (A: aroma, F: flavour, MF: mouthfeel, T: taste).

The contribution of *Saccharomyces cerevisiae* to the extraction and retention of non-volatile components of wine

Macromolecules are known to influence the style and quality of red wine. Wine contains many phenolic substances originating from the grape berry, such as tannins (responsible for the astringency of red wine), anthocyanins (the principal source of red wine colour) and catechins (known for being bitter). Polysaccharides are a chemically diverse group of compounds in wine (derived from both grape and yeast) that affect wine's mouthfeel and taste. Together, polysaccharides and low molecular weight phenolics influence the sensory perception of astringency, viscosity and hotness in wine. While it is known that the degradation of yeast cell walls contributes to high molecular weight polysaccharides in wine, little is known about yeast's ability to more broadly influence the macromolecular profile of wine. In particular, the project team has been focusing on whether there are yeast strain-specific contributions to the wine macromolecular profile.

A laboratory-scale red winemaking trial evaluated 93 different wine yeast strains in Shiraz grape juice. Quantitative analyses of the non-volatile components of the resulting wines revealed a wide range of yeast-derived influences on polysaccharide classes, tannin, and anthocyanin concentrations. Future research will investigate the impact of these differences on wine style, particularly whether the magnitude of the differences is sufficient to affect the sensory perceptions of colour and mouthfeel.

Yeast's effects on varietal thiols in red wine

Varietal thiols such as 3-sulfanylhexan-1-ol (3-SH) and 3-sulfanylhexyl acetate (3-SHA) have been studied extensively in white wines; however, little is known about their formation and sensory impact in reds. The project team screened a group of 15 *Saccharomyces cerevisiae* strains for their ability to release 'tropical' thiols in a Pinot Noir must. There was a marked strain-dependent difference in the varietal thiol concentrations in the resulting wines (Figure 17). What does this reveal about these yeasts? Previous work suggested that moderately high concentrations of thiols are associated with increased 'red fruit' character in Pinot Noir and Grenache. Taken together, these studies indicate that some yeasts previously thought of as best suited for white wine production might also be worth considering for the production of some red wines.

Yeast selection for variable higher alcohol production

The aromatic higher alcohols 2-phenylethanol, tryptophol and tyrosol are yeast-derived compounds that modulate the aroma and palate of fermented beverages such as beer, wine and sake. A group of five variants of the widely used industrial wine strain AWRI 796, previously isolated due to their elevated production of the desirable 'rose'-like aroma compound 2-phenylethanol, were characterised in pilot-scale fermentations of a Chardonnay must. Results showed that these variants increased both the concentration of 2-phenylethanol and modulated the formation of the higher alcohols tryptophol, tyrosol and methionol, in addition to volatile sulfur compounds derived from the amino acid methionine. This work highlights the connections between nitrogen and sulfur metabolism in yeast during fermentation.

The team also monitored the evolution of higher alcohols during wine ageing (storage), focusing on the sulfonation of tryptophol, which yields tryptophol-2-sulfonate, a compound that has been linked with bitterness in wine. The formation of tryptophol-2-sulfonate stabilised after six months in bottle. Longer storage time did not lead to further increases in the concentration of this compound. Sensory analysis of the Chardonnay wines showed that both tryptophol and tryptophol-2-sulfonate were associated with decreased 'sweetness', and a low level of 'bitter taste'. Conversely, in sparkling wines made using strains with a moderate tryptophol-producing phenotype, no significant conversion into the sulfonated form was observed after approximately ten months in bottle. The incomplete conversion of tryptophol to tryptophol-2-sulfonate suggests that the reaction might depend on the physico-chemical characteristics of the wine, such as pH, temperature, SO_2 concentration and O_2 concentration.

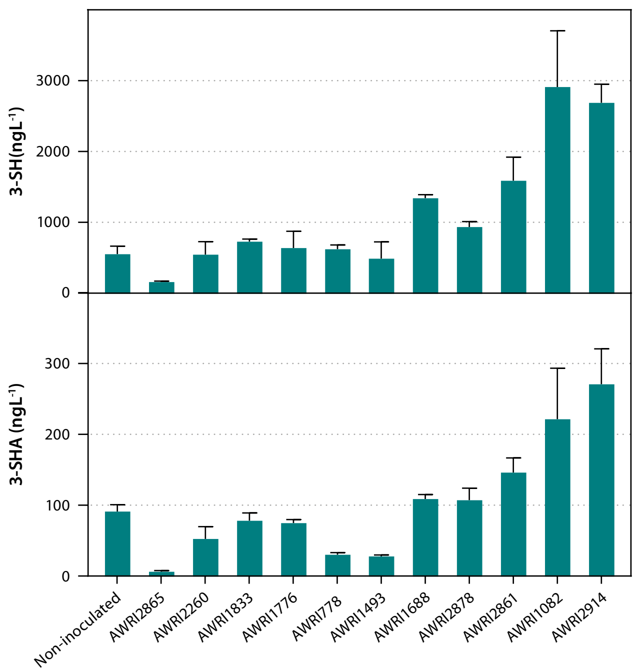

Figure 17. Concentration of 'tropical' thiols 3-SH and 3-SHA in Pinot Noir wines made using 11 different yeast strains and via a non-inoculated ferment. Blue bars show the mean of three treatments with error bars showing standard deviation. The 11 yeast strains are shown in ascending order of their β-lyase enzyme activity.

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

Background

This project brings together yeast and bacterial fermentation to achieve an integrated approach to the study of fermentation performance. The starting point for any ferment, the juice, is a rich ecosystem. 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 (MLF) is increasingly being used to manage winery scheduling more efficiently. The interactions of different microorganisms with the grape juice environment, both individually and as a community, and how those interactions shape fermentation performance, are the focus of this work.

Yeast and bacterial interactions during simultaneous alcoholic and malolactic fermentation

Despite significant improvements in malolactic fermentation (MLF) control, stuck or sluggish MLF issues still occur, particularly in white and sparkling base musts and wines. In these cases, knowledge of yeast and malolactic bacteria strain compatibility becomes an essential factor for successful MLF induction. One of the elements of yeast biology that contributes to its compatibility is the amount of SO_2 a yeast strain produces. Different yeast strains have an enormous range of SO_2 production potential. Laboratory trials have shown that some yeast and bacterial pairs support MLF despite the yeast producing large amounts of SO_2. The project team previously correlated the support of MLF in these cases with the transient production of high concentrations of acetaldehyde.

A pilot-scale vintage trial confirmed the previous laboratory findings that early, yeast-derived acetaldehyde can both enhance bacterial survival during co-fermentation in Chardonnay with high SO_2-producing yeast and enhance MLF performance. These results show that SO_2 production by yeast and the survival of *Oenococcus oeni* following inoculation into an active fermentation can effectively be decoupled. Such enhancement of *O. oeni* survival in fermentations with high concentrations of SO_2 identifies transient acetaldehyde production as a potential 'survival factor' for *O. oeni* in the difficult conditions of white wine co-fermentation. With the idea that transient acetaldehyde production could become a marker for yeast bacterial compatibility, a survey of the acetaldehyde production potential of a more comprehensive selection of *Saccharomyces cerevisiae* yeasts was also undertaken.

Quantifying the genetic response of *Oenococcus oeni* to SO_2

It is well known that high total SO_2 concentrations are a primary factor in the failure of MLF. Over the previous year, the project team undertook a detailed analysis of the genetic factors activated by *O. oeni* after exposure to SO_2. This analysis revealed that *O. oeni* does not contain a specific mechanism to counteract the stress produced by SO_2 but instead relies on the activation of several general stress-response genes. The identity of the activated genes provides a clue as to how SO_2 interacts with the cellular components of *O. oeni*.

The experiments suggest that SO_2 reacts primarily with intracellular proteins, DNA and the cell envelope of *O. oeni*. The cells respond by trying to repair the damaged proteins or by recycling irreparably damaged ones. DNA damage repair mechanisms are also activated. Addition of a higher but still sub-lethal concentration of SO_2 results in arrested growth and an inability to initiate the general stress response. The difference in concentration of free SO_2 that elicits either the general stress response or growth arrest is small (5 mg/L). That such a small change in SO_2 concentration can produce such different effects highlights the narrow margins between successful and unsuccessful MLF.

Investigating interspecies microbial interactions

With non-*Saccharomyces* yeast being more commonly directly inoculated into grape juice, often at high cell densities and before inoculation with *Saccharomyces cerevisiae*, an obvious question to ask is whether some strains are better competitors than others? Are there strain-specific responses of *S. cerevisiae* to the presence of other organisms in their environment? Competitive experiments performed in the previous year using the collection of 94 barcoded strains of *S. cerevisiae* showed substantial fitness differences between *S. cerevisiae* strains in response to the presence of non-*Saccharomyces* yeast species. These observations identified specific strains of *S. cerevisiae* that can better perform in a competitive fermentation scenario where a different yeast species is inoculated first.

In the current year, the project team sought to verify the results of the competition experiments with a series of selected *S. cerevisiae* strains from the barcoded library that had higher or lower fitness when a different yeast species was present. The fermentation performance of the *S. cerevisiae* strains was evaluated in a medium that had previously been inoculated with specific non-*Saccharomyces* yeasts. In general, pre-inoculation with a non-*Saccharomyces* yeast was detrimental to the growth and fermentation performance of *S. cerevisiae*, irrespective of the non-*Saccharomyces* species or *S. cerevisiae* strain pair. However, the pairwise co-inoculation experiments confirmed that some strains of *S. cerevisiae* were indeed more fit to compete with different yeast species than others. Other strains of *S. cerevisiae* were unable to complete fermentation if inoculated into a medium in which a non-*Saccharomyces* yeast had been present for 24 hours.

The general inhibition of *S. cerevisiae* by non-*Saccharomyces* yeasts was previously reported by other research groups worldwide. However, the mechanisms of competition between yeast species are still poorly understood. The increasing use of commercial non-*Saccharomyces* yeast starters and winemaking practices employing spontaneous fermentations are compelling reasons to improve understanding about the interactions between different yeast species.

A set of experiments was conducted to categorise the basis for competition deficiencies evident when readily available commercial non-*Saccharomyces* species are co-inoculated with *S. cerevisiae*. Two approaches were used:

- Direct interactions linked to cell-to-cell contact between the two species were evaluated using inter-species co-cultivations.
- Indirect interactions related to depletion of nutrients or production of antimicrobial metabolites were evaluated using the cultivation of *S. cerevisiae* in non-*Saccharomyces* culture filtrate.

The results from these experiments demonstrated that not all non-*Saccharomyces* yeasts affect fermentation by *S. cerevisiae* in the same way. Inhibition of fermentation by *Metschnikowia pulcherrima* appears to be related to direct interaction with *S. cerevisiae*. Removing *M. pulcherrima* releases growth inhibition. However, species such as *Torulaspora delbrueckii* change the composition of the grape juice in a way that affects the subsequent growth of *S. cerevisiae*.

To further resolve how nutritional deficiencies might be inhibiting fermentation by *S. cerevisiae*, one non-*Saccharomyces* species was selected and the chemical changes produced in grape-like media after their growth were analysed in detail. In the case of

Torulaspora delbrueckii, a depletion of specific amino acids and zinc was observed, which suggested that a deficit of these essential nutritional components might be responsible for the slowed growth and fermentation performance of *S. cerevisiae*. In subsequent work, correction of nutritional deficiencies by supplementation to pre-non-*Saccharomyces* concentrations, surprisingly, did not rescue the *S. cerevisiae* strain from its fermentation performance difficulties. To date, the basis for the inhibition of fermentation by non-*Saccharomyces* yeasts remains unresolved.

Management and optimisation of the AWRI Wine Microorganism Culture Collection

Background

The Australian wine industry is fortunate to have access to a unique repository of wine-related microorganisms (yeast, bacteria and fungi) that dates back more than 80 years (the AWRI Wine Microorganism Culture Collection). This collection both preserves Australia's winemaking heritage and supports the latest research on wine microbiology and molecular biology. Over time, as the collection has developed, the way microbial strains are identified has changed, adapting to the latest scientific knowledge and technologies. Additions to the AWMCC are being continuously incorporated from wineries and researchers across Australia and the world, developing a repository that houses the Australian wine industry's microbial germplasm legacy. 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 native 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 2020/2021, a total of 224 individual yeast and bacterial strains were submitted to the AWMCC by researchers and wineries. During the year, the AWMCC distributed 513 microbial strains from cryogenic stocks to AWRI researchers, wineries and external research partners.

Microorganism species identification is a dynamic area, and species relationships and identities are constantly being updated, so the collection is periodically rationalised with new species designations. The goal is to identify the isolates correctly and efficiently to make the process of screening yeast or bacteria for researchers more relevant, and to be able to provide appropriate cultures for winemakers. Historically, techniques such as microscopic analysis of cell morphology, biochemical and physiological testing have been used to identify microorganisms. However, such morphological and biochemical techniques are increasingly being demonstrated to be prone to inaccuracies. The current method of molecular characterisation is undergoing development to take into account next generation sequencing technologies, and the ability to identify large numbers of organisms via a plate-based system rather than a one-at-a-time methodology. This will have the potential to increase the speed and cost efficiency of molecular identification and will create a curated database of cultures that can be used for a range of purposes.

During the year, a number of strains with unusual fermentation properties were characterised that have potential for use in wine production and other industries. These included a hybrid *Saccharomyces* yeast with high sorbitol fermentation potential, which may be useful in the pharmaceutical industry, and a yeast isolate (AWRI 1213) that appears to ferment fructose but not glucose, which may be useful in low-alcohol beverage production (Figure 18).

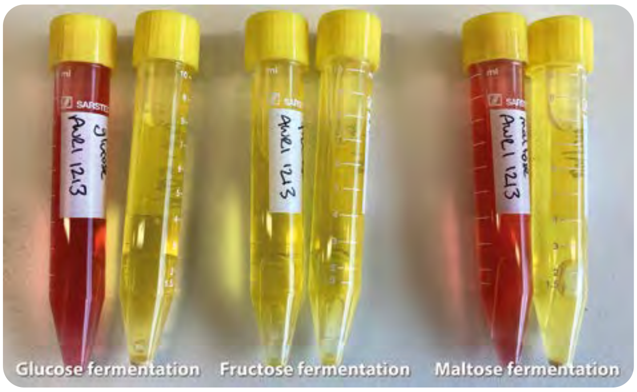

Figure 18. Comparison of the fermentation properties of AWRI 1213 and a control yeast. Red colour indicates no fermentation of sugar; yellow colour indicates fermentation with acid production.

Objective measures of quality and provenance in Australian vineyards

Background

The project formed part of a multi-agency collaboration to research Shiraz terroir across a range of scales, primarily in the Barossa Valley. Twenty-four sites across six sub-regions were monitored, with fruit sampled for ripeness testing, yield assessment, chemical analysis and small-lot winemaking. The 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. Detailed chemical analysis was performed on the small-lot wines at the AWRI, and sensory analysis was conducted at the University of Adelaide as part of the collaboration.

Defining the chemical composition of wines from the Eden Valley and Barossa Valley geographical indications

This collaborative project has completed its fourth and final season. Three years of wine compositional data from the Barossa sub-regions have been compiled. As in previous years, it was found that some discrimination of the Barossa Valley sub-regions could be developed using multivariate modelling of wine compositional data, but only the Eden Valley geographical indication (GI) could be consistently separated from the rest of the Barossa Valley GI over multiple seasons. Flavonoids and C6 volatiles were the two groups of compounds that were significant in describing the Eden Valley wines for each vintage studied. Combining two seasons' data, strong seasonal differences in wine phenolics were found, with wines from the 2020 season having far lower anthocyanin, wine colour density and polymeric pigment than wines from 2019. Irrespective of the season, it was found that Eden Valley wines had consistently lower concentrations of malvidin glucosides. Tannin concentration was generally lower in Eden Valley wines, and tannins tended to be both larger polymers and had proportionally lower prodelphinidin subunits. Since malvidin glucosides and prodelphinidin are both trihydroxylated flavonoids, this could indicate that the growing conditions within this GI reduce flux within this biosynthetic pathway in grapes, possibly a result of distinct climatic differences (Figure 19). In both the 2019 and 2020 seasons, the C6 compounds, particularly Z-3-hexanol, E-2-hexenol and an associated ester (hexyl acetate), were elevated in Eden Valley wines relative to the other Barossa sub-regions. However, it is important to note that this effect was far less marked in 2020 than in 2019. This is relevant since C6 compounds in Eden Valley wines correlated with an increase in 'vegetative' sensory notes in previous seasons, whereas in 2020 this correlation was far weaker. The results generally show that the Eden Valley

GI produces chemically distinct wine relative to the other Barossa sub-regions, but the extent of the response can vary substantially by season. For the remainder of the broader terroir project, a range of data prepared by collaborators will be synthesised with the grape and wine chemical data, including biophysical, soil and grapevine physiology measures. These data will be assessed through both guided and unguided multivariate analysis approaches in order to inform whether unique terroirs within the Barossa Valley can be identified. This may agree with existing GIs or possibly sub-regions, but may potentially reveal other, unique, drivers of terroir.

Growing degree days

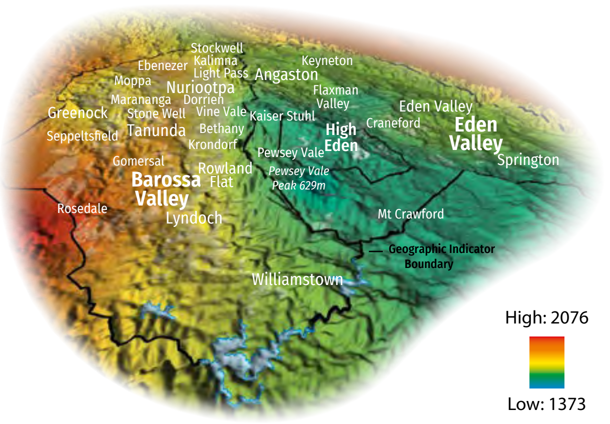

Figure 19. Relief map of the Barossa Valley and Eden Valley GIs showing growing degree days as a coloured scale (image adapted from a Barossa Grape & Wine Association publication and reproduced with permission).

Using historical grape compositional data to explore regionality

A number of studies have been conducted in recent years that involved a comprehensive assessment of Shiraz grape composition, in order to objectively predict wine quality and style outcomes. The compositional database built up over time was re-examined to assess if there is regional variation in Shiraz composition, and if so, to identify analytical approaches which might best discriminate the response of this variety to regional or sub-regional differences. Data on a range of targeted volatile and non-volatile compounds, as well as non-targeted near- and mid-infrared spectra, for grapes from the Riverland, Clare Valley and McLaren Vale were subjected to multivariate modelling. Data generated using both the targeted and non-targeted analytical approaches could discriminate the samples on a regional basis. However, a focused study in the Barossa Valley found that for the targeted analytical approach, within-vineyard variability exceeded between-vineyard variation for some measures, preventing discrimination of vineyards or sub-regions. However, using the data generated from multiple non-targeted analytical approaches, within-vineyard variation was substantially reduced. This enabled Shiraz vineyards to be better defined using a non-targeted 'chemical fingerprint' and showed some potential to discriminate the Barossa sub-regions. This suggests that certain aspects of grape chemistry are more sensitive to site- or region-specific variables than others. Further work could seek to identify individual compounds, or classes of compounds, which most consistently define the terroir response for Shiraz. Using the results of this study, new methods could be developed to quantify the relevant grape or wine metabolites identified using the non-targeted approach, in order to apply these more broadly in studies seeking to objectively characterise terroir.

Development of resources for the objective measurement of grape parameters to address ACCC recommendations

Background

In 2018/2019 the ACCC's Agriculture Unit conducted a market study of the wine-grape industry. The study examined competition, contracting practices, transparency and risk allocation in wine-grape supply chains. This project aims to address some of the recommendations of that study, by developing a range of standardised methods, endorsed by both industry and regulatory bodies, for the measurement of key parameters in grapes; for sampling in the vineyard, in the winery and at the weighbridge; and for validating secondary methods against the reference methods. It will also provide training and tools to support the implementation of standardised methods and assist third parties mediating disputes.

Preparing industry-endorsed standard practices

A major focus of this project has been the formalisation of standard methods for the measurement of the key grape parameters total soluble solids, pH, titratable acidity and colour, and validation of the secondary methods that reference them. The development and review of these standard methods have been guided by a project reference group of representatives from key industry bodies.

Additional protocols have been developed for vineyard sampling and grape assessment at the weighbridge, including sampling practices for matter other than grapes (MOG) and pest and disease. To better understand the sampling practices currently employed in industry, the project team engaged with members of the project reference group to conduct experimental trials during the 2021 vintage. In addition, a sensory procedure was developed for evaluating wines for the presence of specific attributes, particularly those arising from vineyard smoke exposure.

Training and resources

With the formalisation of industry-endorsed standard practices nearing completion, guideline documents and extension activities are being developed to support training for businesses. A series of webinars and training resources will be deployed to support adoption of the standard practices in vintage 2022.

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 in the late 1990s and early 2000s, the risk of 'Brett' spoilage is now commonly managed via a multi-faceted strategy disseminated by the AWRI, which enables winemakers to significantly decrease levels of 'Brett' spoilage compounds in finished wines. However, *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.

Understanding the development of sulfur dioxide tolerance

Whole-genome sequencing of SO_2-tolerant *Brettanomyces* strains isolated from industry between 2004 and 2019 found that these isolates displayed structural genomics changes that included amplification of the SO_2 transporter gene *SSU1*. Laboratory-based directed evolution was also used to assess the ability of *Brettanomyces* strains to evolve higher tolerance to SO_2. Three *B. bruxellensis* strains, representing the known genetic variation within the species, were subjected to increasing sub-lethal sulfur dioxide concentrations. Individual isolates from the evolved populations displayed between 1.6 and 2.5 times higher SO_2 tolerance than the original parental strains. Whole-genome sequencing revealed many structural changes to the genomes of the evolved isolates; however, as seen in the industry isolates, the SO_2 transporter gene, *SSU1*, was amplified in all tolerant clones. This work, combined with the industry isolate testing, clearly demonstrates that as for *Saccharomyces cerevisiae*, alterations in the gene *SSU1* is a key mechanism driving the development of SO_2 tolerance in *Brettanomyces*. This discovery will help guide future work.

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 decrease the risk of undesirable 'reduced' aromas and maximise positive aromas.

Unravelling formation pathways for volatile sulfur compounds

A group of 15 yeast strains were screened for their ability to produce benzylmercaptan (the compound associated with 'struck flint' character in wine) in laboratory-scale ferments in a Pinot Noir must. Only one of the strains, which produced the highest concentrations of hydrogen sulfide of all the strains assessed, was found to produce levels of benzylmercaptan above the limit of quantification of the analytical method (Figure 20). These results could not, however, be confirmed in a Chardonnay juice, as no clear correlation was observed between yeast hydrogen sulfide production and benzylmercaptan levels at the end of fermentation.

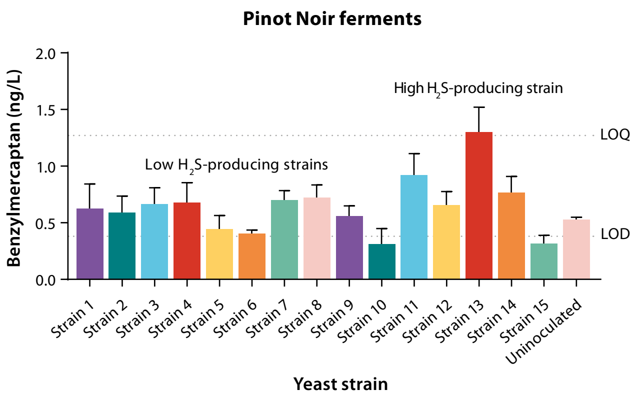

Figure 20. Fifteen yeast strains screened for benzylmercaptan production in Pinot Noir must (LOQ: limit of quantitation, LOD: limit of detection)

The sulfur-containing amino acid methionine is one of the main precursors for the undesirable VSCs methanethiol and methylthioacetate. Both small-scale and pilot-scale Chardonnay fermentation trials showed that the formation of methanethiol and methylthioacetate depended on the yeast starter culture used, as strains with a very active amino acid metabolism were able to divert methionine away from the formation of these odoriferous compounds. When considering yeast genetic determinants responsible for the formation of these compounds, small-scale fermentations in a synthetic must indicated that the yeast alcohol acetyltransferase *ATF1* plays a minor role in methylthioacetate formation. Three alternative genes that might be responsible for methanethiol and/or methylthioacetate formation have also been identified.

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 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 strategies to mitigate the risk of formation of 'reductive' characters, either prior to, or following, packaging in cans.

Evaluating the impact of wine attributes on aluminium transfer

Previous work has shown that aspects of wine composition, including pH and the concentrations of free sulfur dioxide (SO_2), copper, oxygen, chloride and sulfate, can influence the corrosion chemistry at the internal aluminium surface of a can of wine. This can result in the transfer of aluminium into the wine and subsequent reaction with SO_2 to produce hydrogen sulfide, despite the presence of a protective barrier film.

Bench-top experimental trials are continuing to provide more data on the extent to which these different wine parameters affect barrier film integrity and the resulting transfer of aluminium, so that strategies can be put in place to minimise the potential formation of H_2S in canned wine products. This approach will also include the use of cross-linked polymers (PVI/PVP) to remove copper prior to canning, previously reported as effective.

Developing internal packaging capabilities

AWRI Commercial Services has developed the internal capability to package wine-based products into a variety of different packaging formats over the last twelve months. This includes the installation of a dual counter-pressure filler unit and can seamer unit, for packaging of products into a variety of different can sizes and formats. Much work has been undertaken to optimise the filling and packaging process to ensure best-practice performance can be achieved for carbonation, fill consistency and oxygen management.

Smoke taint research and industry support

Background

A new research project on smoke has commenced at the AWRI with funding from Wine Australia and co-investment from the South Australian and Victorian State Governments. Assessing the relationship between the concentration of smoke-derived compounds in grapes and wine, and the intensity of 'smoky' sensory attributes in wine is the major focus. The impact of early-season and late-season smoke exposure is being assessed using grape samples collected across Australia during the 2019/2020 bushfire season, many of which have been made into wine under standardised conditions. In addition, the AWRI is involved in supporting several state-based initiatives launched following the 2019/2020 bushfire season, which aim to build technical capacity at the regional level.

The previous smoke project funded by Wine Australia, the AWRI and the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program was completed in January 2020, and the Final Report is available from Wine Australia's website. Some research themes have been carried through to the new project, notably assessments of amelioration options such as carbon fining, enzyme treatment and choice of yeast strains.

The AWRI is collaborating with the University of Adelaide's Industrial Transformation Training Centre on smoke taint research. During the year, assistance was provided for one PhD project investigating the uptake of smoke molecules in grapes. A collaboration is also in progress with the University of Adelaide, PIRSA, Grain Producers SA and the SA Grain Industry Trust to assess the potential impact of smoke from stubble burns on grapes and wine, with funding from the South Australian Wine Industry Development Scheme. AWRI staff are also collaborating with the National Wine and Grape Industry Centre at Wagga Wagga to understand the impact of winemaking processes on smoke taint.

Early-season smoke exposure in the Adelaide Hills 2019/2020 season

It is now well known that smoke can contaminate wine-grapes via the accumulation of volatile phenols and glycosides, which can contribute to undesirable 'smoky' aromas and flavours in the resulting wines. Model smoke experiments conducted in the early 2000s concluded that at the early stages of grape ripening, when grapes were still hard and green, the risk of smoke taint was low to variable, based on measurement of guaiacol and 4-methylguaiacol, which were the smoke markers available at the time.

During late 2019, the Adelaide Hills region was affected by one major smoke event, which coincided with the early stages of grape ripening (average growth stage E-L 27), and the region was clear of smoke for the rest of the ripening period. This presented a unique opportunity to test the effect of early-season bushfire smoke exposure on wine-grapes and the wines made from them.

Chardonnay, Pinot Noir and Shiraz grapes were sampled from 24 sites across the Adelaide Hills, representing a range of suspected smoke exposure from non-smoke-exposed sites through to vineyards that had experienced direct fire damage but were still able to produce a crop. Replicated berry sampling commenced in mid-January 2020, four weeks after the fire started, and the grapes were harvested in March and made into wines at 50 kg scale. Standard winemaking protocols were applied: Chardonnay was pressed off skins and the clarified juice fermented; Shiraz and Pinot Noir wines were made in a full-bodied style with skin contact. PIRSA and Wine Australia contributed to the trial design, which they also supported with funding.

Smoke exposure early in the growing season clearly led to elevated phenolic glycosides in grapes at harvest for most of the smoke-exposed vineyards studied, corroborating the use of phenolic glycosides as smoke exposure markers during the early stages of grape ripening. The concentration of phenolic glycosides in early-season grapes was not diluted by the increase in berry size during ripening, contrary to expectations.

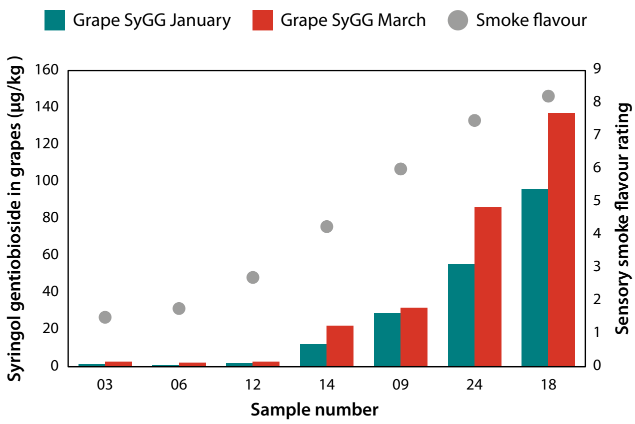

Figure 21. Increase in concentration (µg/kg) of the key smoke exposure marker, syringol gentiobioside, in Pinot Noir grapes from January to March 2020 (at harvest) despite average berry weight more than doubling from 0.42 g/berry in January to 0.98 g/berry at harvest. Teal bars indicate syringol gentiobioside concentration in grapes in January, red bars indicate syringol gentiobioside concentration in grapes in March (at harvest) and grey dots indicate smoke flavour sensory rating of the wines, tasted six weeks after bottling.

A range of concentrations of phenolic glycosides were quantified in the berries at harvest, and later compared with sensory ratings of smoke flavour intensity in the wines. One vineyard very close to the fire front in Woodside (labelled sample 12 in Figure 21), which might have been expected to be smoke affected, did not have elevated phenolic glycosides at harvest. This vineyard was reported by the vineyard manager to have escaped the full force of the smoke plume due to a wind change. Results from analysis of all three varieties at this vineyard were consistent with grapes that had not been exposed to smoke, and this was backed up by the chemical data and sensory assessment of the wines. On the other hand, results from a vineyard located 4 km away from the fire scar to the north demonstrated elevated concentrations of phenolic glycosides (sample 14 in Figure 21), and Pinot Noir wine made from that site had distinct 'smoky' flavours, confirming smoke exposure. These examples showed that smoke exposure may not correlate directly with proximity to the fire. Hence it is important to test for presence of smoke exposure markers in grapes from individual sites and not make generalisations about regions that have been exposed to smoke.

A relationship was seen between the concentration of taint markers in fruit early in the season and sensory assessment of smoke characters in the wines made from such fruit after harvest. The ranking of marker compounds early in the season matched the ranking of smoke characters in the wines (Figure 21). This relationship was particularly strong for the lighter Pinot Noir wines. While the ranking of marker compounds early in the season matched the ranking of smoke characters in the Shiraz wines in general, dominant 'green'/'eucalyptus' characters seemed to mask the 'smoky' flavour in one wine, particularly when assessed six weeks after bottling.

For the Chardonnay wines the ranking of smoke marker compounds early in the season matched the ranking of smoke characters in the wines, but the wines were rated much lower in 'smoky' flavour than the red wines. This likely reflects the winemaking process for white wine, which involves early removal of the grape skins, resulting in minimal skin contact, whereas red wine production involves skin contact, aligning it more closely with the grape analysis which involves extraction from all grape components, including skins.

Lessons from the Australian 2019/2020 bushfire season beyond the Adelaide Hills

A number of sample sets have been created to understand the sensory impact of smoke exposure on wines made without any remediation treatments. These include 23 wines from Adelaide Hills wines, 42 wines from various regions across south-eastern Australia, 110 micro-ferments from the Adelaide Hills and 41 micro-ferments from various regions. Sensory and chemical analysis have been completed for all samples.

A dilution/blending study to assess the consumer rejection threshold for 'smoky' characters in Chardonnay was conducted with 124 consumers. The results showed that consumers responded negatively to blends with 50% or more of the smoke-affected Chardonnay in a clean control wine, with many consumers also giving low liking scores to the 25% blend. A similar study with a full-bodied red wine is planned for next year.

Smoke flavour intensity in wine was generally related to the concentration of guaiacol, cresols and glycosides. The smoke markers were highly correlated, with some varietal differences, in line with previous observations. No wines had 'smoky' flavour that could not be explained by the measured volatile phenols and their glycosides, although some attributes that can be confused with smoke were identified. Masking of smoke by 'green capsicum', 'eucalyptus' and 'tropical' notes was also observed.

Industry support activities

Through a partnership with Wine Victoria and funding from the Victorian Government, the AWRI developed a process for establishing sensory assessment panels in four key regions. Wine benchmarking test kits were prepared and distributed to producers and regional associations, which included wines with various levels of smoke compounds, provided with associated chemical and sensory data. A study was also undertaken to cross-validate results between the two principal laboratories in Australia that offer smoke taint analysis, but use somewhat different methods. A report on the results of this study is available from the smoke page on the AWRI website. Further trials are also underway testing a range of winemaking techniques and processing aids for remediating smoke-affected wine, the outcomes of which will be presented at a series of sensory workshops for winemakers. The smoke marker compounds background database, which started in 2011, has been further expanded to include an additional five varieties important in Victorian viticulture. A similar activity is also underway in NSW, with a focus on five varieties important in NSW regions. This project, funded by New South Wales Wine, is also creating a dataset from the grape chemical analytical data from AWRI helpdesk investigations.

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, social 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

Sheridan Barter, Dr Anthony Borneman, Danielle Carter, Megan Coles, Kate Cuijvers, Assoc. Prof. Leigh Francis, Laura Hale (from 27 January 2021), Prof. Markus Herderich, Dr Mark Krstic, Dr Mardi Longbottom, Dr Cristobal Onetto, Dr Wes Pearson, Liz Pitcher (from 8 February 2021), Dr Michael Roach (to 24 December 2020), Dr Simon Schmidt, Dr Tracey Siebert, Steven Van Den Heuvel, Dr Cristian Varela, Chris Ward (from 15 March 2021), Dr Eric Wilkes.

Students

Lisa Hartmann (University of Adelaide) (to 31 July 2020).

Collaborators

Adelaide Hills Vine Improvement Incorporated (Prue Henschke, Craig Markby, Louise Christian, David Coleman); Australian Grape & Wine (Tony Battaglene, Anna Hooper); Food Agility Cooperative Research Centre (Karensa Menzies, Cameron Ralph); Freshcare Ltd (Angela Steain, Fiona Grime, Jane Siebum); McLaren Vale Grape Wine & Tourism Association (MVGWTA) (Jennifer Lynch, Rachel Williams); SARDI (Dr Suzanne McKay, Dr Mark Sosnowski); Sustainability Advisory Committee (Shae Courtney, Philip Deverell, Mandy Gerhardy, Anton Groffen, Sean Howe, John Ide, Madeline Jarrett, Chelsea Jarvis, Jennifer Lynch, Cath Oates, Ben Pridham, Hayley Purbrick, Kyra Reznikov, Brett Rosenzweig); Wine Australia (Stuart Barclay, Andreas Clark, Steve Guy, Drea Hall, Alex Sas); Yalumba Family Winemakers (Greg Nattrass).

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

Background

Launched in 2019, Sustainable Winegrowing Australia is Australia's national program for grapegrowers and winemakers to demonstrate and continuously improve their sustainability in the vineyard and winery through the environmental, social and economic aspects of their businesses. The program takes a holistic approach to managing, supporting and promoting sustainability. In 2020, Australian Grape & Wine, the AWRI and Wine Australia signed a Memorandum of Understanding outlining the collaborative arrangements for governance and delivery of Sustainable Winegrowing Australia. Sustainable Winegrowing Australia is governed by a joint steering committee with representatives from Australian Grape & Wine, the AWRI and Wine Australia. The roles of the three partner organisations are as follows:

- Australian Grape & Wine provides oversight and guidance of the program, liaises with the Australian Government and state governments and consults with the sector's key stakeholders on policy and development.
- The AWRI provides program management, membership administration, technical development, and extension and adoption activities.
- Wine Australia provides marketing and communications to help attract and retain members and to promote Australia's sustainability credentials to key stakeholder groups globally.

Membership

In 2020/2021 program membership increased by 23% to 631 (90% vineyard members and 10% winery members), with certified members representing 15% of total members. The increase in membership reflects increased confidence and familiarity with the new governance and delivery arrangements of the program. There is also significant and growing demand for certified membership of Sustainable Winegrowing Australia from across the sector, with certification training delivered to 91 members during the year. This training is an essential requirement of certification to ensure that the program is interpreted and implemented successfully.

Trust mark

The Sustainable Winegrowing Australia trust mark, developed as a co-investment between the AWRI and Australian Grape & Wine in 2020, became available for use by certified members on wine labels and marketing materials in June 2020. The trust mark completed registration with IP Australia in December 2020 and was accepted in the EU, UK, NZ and the USA. During the year, 17 applications for use of the trust mark on wine labels by certified members of the program were approved and 38 farmgate signs featuring the trust mark were delivered to certified members.

Industry engagement

COVID-19-related travel and gathering restrictions posed some challenges to the delivery of industry engagement activities; however, the transition to online and hybrid online/face-to-face workshop delivery was well received. Participants in online certification training workshops reported an average overall workshop rating of 88% at post-event surveys. During the year the Sustainable Winegrowing Australia team delivered 11 workshops and 19 presentations to regional groups across Australia and developed five new member case studies. A new standalone website for the program was launched in April 2021.

Dr Mardi Longbottom is a member of the Australian Grape & Wine Sustainability Advisory Committee (SAC) and provided contributions at four meetings during the year. The project team also coordinated a working group of SAC members who provided guidance and input into a major review of the Sustainable Winegrowing Australia workbook.

Clonal mapping of Pinot Noir

Background

Pinot Noir is one of the highest value grape varieties in Australia, with sales of grapes contributing $5.7 million annually to the South Australian wine industry and representing 60% of the value directly generated from Adelaide Hills red grapes. Of the 672 ha of Pinot Noir grown in the region (42% of SA's Pinot Noir), more than 35% was burnt in the December 2019 Cudlee Creek fires. This resulted in the loss of more than 2,000 tonnes of grape production and significant losses in revenue for around 60 Adelaide Hills producers. Prior to the fires, the Adelaide Hills region had the highest number of Pinot Noir source blocks in SA. The bushfire destroyed 6 out of 28 source blocks, significantly reducing the supply of high-demand clonal planting material. Being able to conduct definitive clonal identification of alternative sources of planting material will decrease recovery time and improve income for wine producers in the region. Funding for the project is provided by the State Government of South Australia, through the SA Wine Industry Development Scheme, Adelaide Hills Vine Improvement Inc., the AWRI and Wine Australia.

Genome sequencing of Pinot Noir germplasm

This project is applying state-of-the-art whole-genome sequencing of a broad range of Pinot Noir germplasm to develop a foundational dataset on genetic diversity in key Pinot Noir clones used for grape and wine production. During the year, key sources of Pinot Noir germplasm were identified and sampled for whole-genome sequencing and used to determine markers for clonal comparison. In-depth analysis has mapped out clonal genetic relationships that are now being used to guide the selection of appropriate germplasm for the establishment of new source blocks.

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.

Mapping microbial communities in a winery

For the wine sector, metagenomics has provided detailed knowledge of the microbial diversity present on grapevines, in vineyard soil and in grape must. Food processing facilities, including wineries, are designed to not only ensure a consistent product, but also one that is safe for consumption. Despite careful hygiene, these facilities contain thriving microbial ecosystems which originate from raw substrates or other materials. In the case of the winery environment, grapes bring different bacterial and fungal populations, depending on variety, origin and harvesting practices. Although some resident microorganisms may not negatively affect the final product, spoilage microorganisms can be detrimental for quality, generating substantial economic losses.

As a proof-of-concept, metagenomics techniques were used to map the microbial communities at the Hickinbotham Roseworthy Wine Science Laboratory on the Waite Campus, before, during and after the 2020 vintage (Varela et al. 2021). Resident bacterial and yeast populations changed over time, with both relative abundance and location within the winery varying according to sampling date. Vintage, the period when grapes are being processed in the winery, caused most of the changes in microbial structure, particularly for bacterial populations. Although fungal communities also changed during vintage, these changes were smaller than those observed for bacterial populations. The exception to this was *Saccharomycetes,* which showed approximately four times higher relative abundance during vintage than prior to this period. Mapping the spatial distributions of the microbial populations identified the main locations that harboured these resident microorganisms (Figure 22). This also included the wine spoilage genera *Lactobacillus*, *Acetobacter*, *Gluconobacter* and *Brettanomyces,* which were found mainly after vintage. Thus, the methodology described here can provide crucial information to wineries and other food processing facilities, helping to identify locations that need thorough disinfection and evaluate the efficacy of the existing sanitation practices.

Reference

Varela, C., Cuijvers, K., Borneman, A. 2021. Temporal comparison of microbial community structure in an Australian winery. *Fermentation* 7(3): 134.

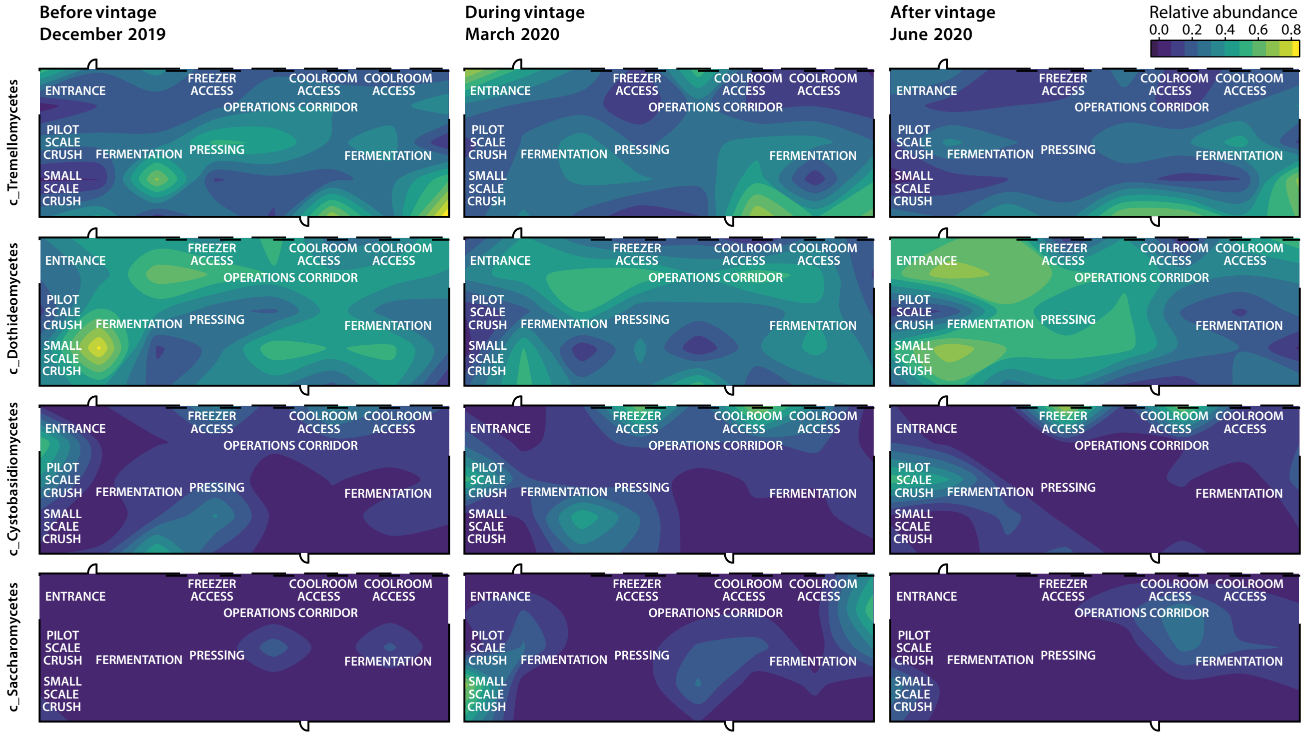

Figure 22. Mapping of the most abundant fungal classes found at the Hickinbotham Roseworthy Wine Science Laboratory, including *Tremellomycetes*, *Dothideomycetes*, *Cystobasidiomycetes* and *Saccharomycetes*, before, during and after vintage (Varela et al. 2021)

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 collaborative project with CSIRO focused on premium cool-climate Shiraz, with the aim of defining features at the within-vineyard scale that contribute to rotundone formation. The research explored if genetic features in grapevine planting material (which may be transferable through propagation and between vineyards) or environmental features (which are site-specific and might be influenced by management practices) contribute to distinctive aroma attributes. This project was completed during the year, with a Final Report available from Wine Australia's website.

Summary of overall project findings

This project has found that development of the sought-after 'peppery' aroma from rotundone in Shiraz grapes appears to depend on site characteristics and environmental factors that regulate sesquiterpene biosynthesis, rather than genetic determinants of planted vines. Overall, it has provided science-based evidence supporting the concept of terroir, demonstrating how the interplay of site, viticultural management, climatic and environmental/biological effectors (which are yet to be identified) shape distinct sensory attributes in Shiraz wine. From a practical management perspective, a very late harvest date was demonstrated as being key to achieving elevated grape rotundone concentrations. This is because extensive formation of the immediate rotundone precursor α-guaiene, and subsequently rotundone itself, typically only commences well after veraison. The importance of harvest date provides an explanation as to why higher grape rotundone, and consequently 'peppery' aromas in wine, are typically found in very high premium Shiraz from cool-climate regions where such late harvest is commercially viable. Further research and insights into the environmental regulation of sesquiterpene biosynthesis in Shiraz are required to retain the desirable, but elusive, 'peppery' flavours in existing cool-climate vineyards by preserving the responsible environmental and/or biological triggers. In addition, such knowledge could potentially allow Shiraz grapes with 'cool-climate-like' flavour attributes to be grown in warmer/hotter regions. Ultimately, the findings of this project represent an important step towards mitigating risks from climate change, biodiversity loss or viticultural management decisions, which might otherwise lead to unintended flavour consequences in Shiraz.

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.

Understanding the population genetics of grapevine trunk disease in Australia

DNA sequencing was used to investigate the population genetics of the grapevine trunk disease pathogen *Eutypa lata*. Forty-four Australian isolates of *Eutypa lata* were subjected to whole-genome sequencing and comparative genomics in order to assess population structure and to provide a resource to assess potential genetic loci that are associated with markers of increased pathogenicity.

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

Thomas Almond (to 4 February 2021), Manreet Bansal (from 31 May 2021), Caroline Bartel, Sheridan Barter, Ida Batiancila, Kate Beames, Linda Bevin, Laura Bey, Eleanor Bilogrevic, Catherine Borneman, Mark Braybrook (to 17 July 2020), Natalie Burgan, Alfons Cuijvers, Georgia Davidson (from 26 October 2020), Chris Day, Dr Zung Do, Shiralee Dodd, Kerri Duncan (from 19 October 2020), Damian Espinase Nandorfy, Angus Forgan, Assoc. Prof. Leigh Francis, Josephine Giorgio-Ion, John Gledhill, Robyn Gleeson, Dr Nuredin Habili, Jesse Hall, Kate Hardy, Thomas Hensel, Prof. Markus Herderich, Kieran Hirlam, Dr Josh Hixson, Adam Holland, Leanne Hoxey, Wen-Hsiang (Denny) Hsieh (from 21 June 2021), Kinga Kiziuk (to 15 December 2020), Dr Vilma Hysenaj, Pauline Jorgensen, Dr Mark Krstic, Jillian Lee, Desireé Likos, Dr Natoiya Lloyd, Brigitte Lynch, Jacinta McAskill, Bryan Newell, Dr Luca Nicolotti, Dr Simon Nordestgaard, Jennifer O'Mahony, Kara Paxton, Shaley Paxton (to 24 December 2020), Dr Wes Pearson, Lisa Pisaniello, Dr Amy Rinaldo, Ella Robinson, Dr Tony Robinson (from 17 August 2020), Marco Schoeman (to 18 September 2020), Neil Scrimgeour, Gina Sellars, Dr Tracey Siebert, Dean Smiley, Mark Solomon, Pamela Solomon, Fang Tang, Dr Maryam Taraji, Randell Taylor, Don Teng (from 19 October 2020), Heather Tosen, Dr Lieke van der Hulst, Flynn Watson, Kylee Watson, Caitlin Wellman (from 18 January 2021), Rachel West (from 18 January 2021), Dr Matthew Wheal, Dr Eric Wilkes, Paul Witt, Qi Wu.

Visiting researcher

Dr Jang Eun Lee (Korea Food Research Institute, South Korea) (to 5 February 2021).

Collaborators

AB Biotek (Dr Tony Balzan, Dr Caleb Cheung, Dr Anthony Heinrich, Dr Tina Tran); Australian Institute for Bioengineering and Nanotechnology (Dr Esteban Marcellin Saldana); Compusense, Canada (Ryan Corrick); CSIRO (Dr Christopher Davies); Queen Victoria Museum & Art Gallery (Tracy Puklowski); Oenotan (Sara Ferreira); SARDI (Dr Marcos Bonada, Dr Joanna Gambetta); University of Adelaide (Assoc. Prof. Cassandra Collins, Assoc. Prof. Paul Grbin); University of Melbourne (Prof. Malcolm McConville); University of Western Australia (Assoc. Prof. Michael Clarke); Wine Industry Technical Advisory Committee (Jonathan Breech); Wine Australia (Rachel Triggs).

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, workplace 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. Administrative support was also provided to entities such as the Australian Wine Industry Technical Conference, Interwinery Analysis Group and the Wine Innovation Cluster. Other notable activities included managing the ongoing impacts of COVID-19 on the AWRI's asset base, cashflow and liquidity; assisting in the formalisation of leasing and collaboration agreements; financial modelling and business case development in support of a range of strategic and capital investment initiatives; and ensuring ongoing compliance with various evolving accounting standards.

Human resources

The AWRI's human resources capability maintains responsibility for a broad range of functions including recruitment, employment contract management, visas, payroll and compliance activities. In 2020/2021 the AWRI continued the migration of many employees from fixed-term to permanent contracts of employment, supporting its ability to attract and retain world-class talent. An internal Leadership Development Program was launched, aiming to provide high-performing staff who exhibit leadership potential with practical experience, formal training and other opportunities for personal and professional growth. The initial cohort of this program, as well as other employees, undertook a range of professional development activities during the year, a number of which were funded through many AWRI Directors nominating for their directorship fees to be made available for such purposes, for which their support is gratefully acknowledged. The annual staff survey once again highlighted the AWRI's positive working environment, with 95% 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; close engagement with industry; and the AWRI's well equipped and modern facilities.

Operations

In July 2020 responsibility for operations management transferred to the AWRI's Research Laboratory Manager, Angus Forgan, in an expanded role following the retirement of the AWRI's long-serving Operations Manager, Mark Braybrook. This role has responsibility for a range of workplace health and safety activities including chairing the AWRI's Safety Advisory Committee and oversight of periodic safety inspections and assurance programs, chairing the AWRI's Institutional Biosafety Committee, maintenance of Office of the Gene Technology Regulator accreditation, and auditing and maintenance of the five Physical Containment Level 2 (PC2) laboratory facilities used for specialised research on genetically modified organisms. Operations management activities continued to include the delivery of engineering and infrastructure solutions for various AWRI groups and projects, most notably the successful commissioning of a new NMR Research Laboratory within the AWRI's premises, which provides a dedicated and secure space for a new NMR and other specialised analytical equipment. Other infrastructure solutions included preparations for installation of a new mass spectrometer within the Commercial Services Trace Analysis Laboratory, and an organisation-wide review of space usage in response to constraints across the AWRI's laboratory, office and storage areas and a planned expansion in capabilities. Operational measures implemented in response to the ongoing COVID-19 pandemic remained an important area of focus, including physical measures such as splash shields and signage, the management of visitors and contractors and a range of other actions to maintain productivity while ensuring staff welfare. The AWRI continues to work closely with the University of Adelaide and other co-location partners, including on the development of a campus Bushfire Management Plan.

Corporate governance and legal support

During the year the AWRI Board welcomed three new elected Directors and one new Special Qualification Director. All Directors participated in comprehensive induction sessions prior to their first meeting to assist in preparation for their role. The Board commenced a review of Board composition and appointment processes, the outcomes of which are expected to be implemented in 2022 following a stakeholder consultation process. The Board also participated in a workplace health and safety update session with a focus on COVID-19-related developments such as working from home. Other activities included maintaining good corporate governance processes in relation to risk management, policy review and contract management.

Information technology

In addition to provision of the usual IT support services to all employees, delivery continued of a range of strategic initiatives which saw the substantive completion of the AWRI's *IT Strategic Plan 2019-2021*, on time and under budget. Key achievements during the period included the enhancement of network capabilities, an expanded back-up program and a range of IT security enhancements. Significant resources continued to be directed towards supporting remote working arrangements in response to the operational challenges of the COVID-19 pandemic. Providing resilience against cybersecurity threats continues to be a key organisational priority and is likely to represent a core focus of the next *IT Strategic Plan*, to be developed over the coming year.

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 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.

Use of Office 365 and SharePoint Online

Office 365 and SharePoint Online are key collaboration tools used by AWRI staff to manage and share files and information. These cloud-based services enabled many staff to work efficiently from home during COVID-19 lockdown periods. Staff seminars are now held virtually using Microsoft Teams. A new workflow for the submission and approval of staff personal development plans was developed using a mix of SharePoint Online, Office 365 and Power Automate.

AWRI 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. AWRI Commercial Services also continues to be actively involved in pre-competitively funded applied research projects and provides services to the broader agricultural industry and producers of other foods and beverages.

Smoke testing

The Commercial Services laboratories had another strong year with total sample numbers for 2020/2021 (28,710) 16% higher than the 2018-2020 average (24,754). There were 212 new customers in 2020/2021, demonstrating growing demand for the services provided.

The impacts of fires continued with a total of 4,252 samples analysed for smoke, of which 2,164 (49%) were from the USA. This compares to a total of approximately 600 samples analysed for smoke in an average year. As part of continual improvements to smoke analysis, new instrumentation was validated for the determination of smoke glycosides, and changes were made to the laboratory information system to allow graphical results to be automatically included in reports, allowing easier interpretation of results and reducing turnaround times. Initial trial work was also completed on the application of mid-infrared spectroscopy to screen grape samples for smoke impacts, a method that can return results in minutes rather than days. While not suitable to replace the current reference methods, this technology has the capacity to identify very clean or highly smoke-affected samples, potentially reducing the numbers of samples that need the more time-consuming mass spectrometric analysis, decreasing instrument congestion and improving the speed of the testing service.

Streamlining biological testing

In the applied biosciences area, 1,391 samples were submitted for virus testing (5% fewer than in 2019/2020) and 3,700 samples were submitted for microbiological testing (22% more than in 2019/2020). This year there has been a strong focus on modernising the systems used for virus detection. Streamlined processes within the laboratory have improved efficiency and delivered faster turnaround times. The number of manual steps have been reduced, which not only saves costs but also reduces the chances of errors. Considerable progress has been made towards the introduction of qPCR testing technology, which will further streamline virus testing and improve the certainty of results. Cross-validation studies with the other major virus testing laboratory within Australia were also carried out, demonstrating good alignment of results.

Bringing new services and technologies to industry

The range of technical offerings provided by AWRI Commercial Services to support the Australian wine industry continues to grow, ensuring that the latest technologies and science are available to clients. During the year, a significant number of shelf-life studies were carried out on a range of wine-based products, including some low- and no-alcohol products. In order to better support these types of studies, further work was carried out to optimise and extend the group's dedicated small-scale packaging facility. This now includes the ability to incorporate bottles, kegs and cans of varying sizes and formats, as well as a range of different closure application tools.

The breadth of sensory services being offered to industry has also been expanded, to incorporate rapid profiling methods such as napping and Pivot©profile, as well as targeted consumer studies, to help inform product development and benchmarking. The development of a customised wine quality assessment procedure for potentially smoke-affected wines has provided a robust sensory method for smoke-related aroma and flavour characteristics in wines and other alcoholic beverages.

Proof-of-performance studies on a number of new analytical instruments were carried out in conjunction with AWRI Commercial Services' internationally recognised analytical laboratory. These studies will help ensure that instrumentation offered to the Australian wine and grape industry meets the expectations required for the production of high quality and consistent products.

Research services

Background

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

Sensory analysis

In the past 12 months, a major effort involved running 82 smoke panel sessions for projects involving both industry and research samples. As part of this, an expanded group of smoke-sensitive assessors was screened and trained. Sixteen quantitative descriptive analysis studies (not including smoke studies) and several shelf-life studies were run, with 24 technical quality panel sessions completed. Seven difference test sessions, 32 bench-style tastings, and 2 consumer liking studies were also undertaken. A group of 20 new part-time casual panellists were recruited and integrated into the existing panels. A further 12 internal AWRI staff were incorporated into the difference testing panel pool. An evaluation of difference testing methodology compared to outcomes from quantitative descriptive analysis and projective mapping methods showed that sensory projective mapping can be sensitive enough to provide reliable and valid conclusions regarding within- and between-treatment sensory differences.

Synthetic organic chemistry

Several new deuterated analytical standards were synthesised for analytical methods for smoke taint compound quantification, compounds related to oxidative flavour and fermentation-derived aroma compounds. Support was provided for NMR characterisation analyses and for *Brettanomyces* binding assays. A new relationship with a commercial chemical synthesis provider was established, which allowed complex molecules to be obtained for smoke taint work.

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.

2021 vintage

WIC Winemaking Services processed 250 research wines (6-100 kg) and 3 commercial (1-2 tonne) batches of wine during the 2021 vintage, made up of 22% white wines (20% in 2020) and 78% red wines (80% in 2020). One client accessed the pro-rata service for blending, filtration and bottling. The busiest weeks in the winery were the last week of February and the first two weeks of March, approximately a week earlier than previous years. The peak plateaued towards the end of March and then a slower but steady intake occurred in April. Coonawarra fruit that was forecast to begin arriving after Anzac Day and into May all ripened earlier than expected and all fruit had been received by 24 April 2021. There will be a record number of agrochemical studies in the second half of the calendar year, which will provide an ongoing stream of work to complement bottling operations.

During the year WIC Winemaking Services again expanded its capability, conducting some small-scale beer brewing trials for an external client. It is hoped that this type of diversification will help support a sustainable business model for WIC Winemaking Services into the future, particularly if demand for winemaking services declines.

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 WA, Victoria and Queensland. Metabolomics SA operates as a collaborative service platform that provides public and private researchers and industries with support, services and training, as well as access to infrastructure and specialist expertise.

NCRIS-enabled Metabolomics Australia services and expertise

In 2020/2021, Metabolomics SA broadened its services and expertise for metabolomics research by adding advanced high-resolution mass spectrometry and liquid state 400 MHz NMR spectroscopy. Priority areas for research collaborations included environmental science, animal science, food and beverage production, biomedical science and the gut microbiome. Metabolomics SA supported commercialisation and performance testing for new fermentation solutions by establishing flavour and aroma profiles using mass spectrometric analysis.

An international collaboration with a visiting scientist from Korea Food Research Institute led to further insight into yeast interactions and nutritional components during fermentation, with work conducted using non-targeted metabolomics and high-resolution mass spectrometry. New partnerships were formed with the South Australian Genomics Centre and the University of South Australia's Mass Spectrometry and Proteomics Facility, which will enhance 'omics' support for researchers and industry. The facility continued to provide hands-on training for Australian and international scientists, with topics including sample preparation techniques, instrument operations and bioinformatics.

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.

Leveraging the AWRI's foundational data

An emerging topic in the global wine industry is a possible future requirement for wines to be labelled with their energy content. Given the wide variety of wines and the potential variability of energy contribution from different components, calculating values that are both accurate and meaningful to the consumer poses some challenges. This is compounded by the fact that some contributing components (such as glycerol) are not routinely measured, as well as the emergence of low- and no-alcohol wines. To support the wine industry in preparing submissions to regulatory authorities on the best approach for energy labelling, the project team reviewed the composition of more than 10,000 wines submitted for analysis between 2016 and 2020 using the AWRI Commercial Services database. These data were used to create a snapshot of the typical composition of Australian red and white wines, as presented in Table 5.

Because glycerol results were not well represented in the AWRI Commercial Services database, a survey of a random selection of 30 white and 30 red commercial wines was carried out. Results are presented in Table 6.

The median values for glycerol in red wines were significantly higher than those for white wines. This is in keeping with literature for overseas wines and is related to the increased skin contact in red winemaking as well as the contribution to glycerol from secondary fermentation. Glycerol data was also obtained for a range of low-alcohol products donated by industry partners, showing that in general the glycerol concentrations in these products were consistent with the ranges seen for products with typical alcohol levels. These data, in conjunction with the typical wine component values in Table 5, will be extremely valuable for determining the best approach for energy content labelling, ensuring that any future regulatory framework reflects both consumers' and industry's needs.

Table 5. Median values for Australian wine composition, based on more than 10,000 samples analysed by AWRI Commercial Services between 2016 and 2020

	Alcohol (%, v/v)	pH	TA (g/L, as tartaric acid, pH 8.2)	VA (g/L as acetic acid)	Sugar (g/L, glucose + fructose)
Red wines	14.2	3.60	6.2	0.57	1.0
White wines	12.4	3.27	6.3	0.33	2.2

Table 6. Glycerol content in commercially available Australian wines surveyed

	Number of samples (n)	Mean glycerol concentration (g/L)	Standard deviation	1st quartile	Median	3rd quartile
White wines	30	5.64	1.06	5.03	5.35	5.88
Red wines	30	9.58	1.16	8.93	9.60	10.08


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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 2021.

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	-	4	4
Ms Wendy Cameron	1 Jan 2018	31 Dec 2020	2	2
Ms Patricia Giannini	16 Sep 2020	-	4	4
Mr Iain M. Jones	1 Jan 2018	31 Dec 2020	2	2
Prof. Kiaran D. Kirk	1 Jan 2017	-	4	4
Dr Mark P. Krstic	1 Feb 2020	-	4	4
Ms Elizabeth A. Riley	1 Jan 2012	-	4	4
Mr Brett M. McClen	1 Jan 2021	-	2	2
Mr T. Nigel Sneyd	1 Jan 2021	-	2	2
Mr Mark R. Watson	24 Jun 2008	31 Dec 2020	2	2
Mr Marcus Y. Woods	19 Oct 2018	14 Mar 2021	3	3
Ms Corrina N. Wright	1 Jan 2021	-	2	2

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 2021 the Company recorded a surplus of $296,305 (2020: surplus of $1,545,122). This surplus primarily relates to the recognition of $854,867 in funding for the purchase of capital equipment (2020: $1,635,262), and requiring recognition as income within the reported upon period in accordance with applicable accounting standards. Corresponding capital expenditure, funded through this capital income as well as internal sources, totalling $1,270,740 was incurred during the year (2020: $2,327,644) and will predominantly be expensed in future periods over those assets' useful lives.

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 2021-2023*, clustered into five themes:

- Best-practice governance and organisational structure
- World-class people and culture
- AWRI business infrastructure, systems and processes
- Future funding, capabilities and services
- Relationships, partnerships, engagement and communications.

The 8-Year Research, Development and Extension Plan *The AWRI 2017-2025*, together with a status summary of the 50 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 2021-2023*, 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 though the achievement of specific milestones, outputs and performance targets as articulated in *AWRI Directions–Business and Operational Initiatives 2021-2023,* the 8-Year Research, Development and Extension Plan *The AWRI 2017-2025* and individual project plans, combined with measures of use of the AWRI's extension platforms and metrics relating to awareness, adoption, value creation and service quality generated through engagement with stakeholders consisting predominantly of grapegrowers and winemakers. 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, 30 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), GAICD
Experience: Principal of Bekkers Consulting and Bekkers Wine. Active as a viticulture and wine business consultant across Australia. Twenty-seven years' experience in viticulture and wine business. Formerly General Manager/Senior Viticulturist of Paxton Wines. Previously director of the McLaren Vale Grape, Wine and 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 MW, Non-executive director (to 31 December 2020)
Qualifications: BAppSc (Biochem and Microbiol) MSc (Biochem), BAppSc (Wine Sci), GradDip (Ed), GradCert (Bus), DipModLang (French)
Experience: Winemaking consultant, previously Head of Winemaking at Brown Brothers Milawa Vineyards. Over 29 years' experience in the Australian wine sector including winemaking, wine show judging and wine business. Fellow of the ASVO, 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.

Ms Patricia Giannini, Non-executive director (from 16 September 2020)
Qualifications: BEc, GradDipAcc, CA
Experience: Associate Director and CFO Advisor at Chapman Capital Partners, with a diverse finance background including within the audit division of 'Big Four' accounting firm KPMG, as well as a range of CFO and consulting roles. More than 25 years' experience in corporate finance and advisory working across a range of sectors including technology, agriculture, mining and finance. Previously a Facilitator in Audit and Financial Reporting for the Institute of Chartered Accountants, and currently involved in advising clients across a diversity of sectors in capital raising, general business consulting, M&A and CFO advisory.
Special Responsibilities: Ms Giannini is the Chair of the Audit committee.

Mr Iain M. Jones, Non-executive director (to 31 December 2020)
Qualifications: BSc, MSc
Experience: General Manager–Technical Services at Treasury Wine Estates. Over 21 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 Australian Grape and Wine 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 25 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.

Dr Mark P. Krstic, Managing Director
Qualifications: BAgSc (Hons), PhD, MBA, GAICD
Experience: Chair of The Australian Wine Industry Technical Conference, Director of the National Wine Foundation, Director of the South Australian Genomics Centre, professional member of the ASVO, member of Hort Innovation's Table Grape Strategic Investment Advisory Panel,

member of the National Viticulture Biosecurity Committee, Associate Editor of the *Wine & Viticulture Journal*, Committee Member of the Wine Innovation Cluster Leadership Group and the Waite Strategic Leadership Group, Honorary Senior Fellow at the University of Melbourne, Adjunct Professor at Macquarie University. Graduate of the Australian Wine Industry Future Leaders Program and 2020 ASVO Viticulturist of the Year.

Mr Brett M. McClen, Non-executive director (from 1 January 2021)
Qualifications: BAgSc (Hons), MBA
Experience: Chief Viticulturist Brown Family Wine Group. More than 20 years' viticultural and management experience across a range of Australian wine regions, as well as experience working with other irrigated horticultural crops. Professional member and previously a Director of the ASVO, finalist in the 2019 ASVO Viticulturist of the Year award.
Special Responsibilities: Mr McClen is a member of the Audit 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, 28 years' experience in the Australian wine industry. 2017 ASVO Viticulturist of the Year.

Mr T. Nigel Sneyd MW, Non-executive director (from 1 January 2021)
Qualifications: BAppSc (Wine Sci), DipNat (Oenol), MBA
Experience: Global Director of Wine, Quality and Compliance for Accolade Wines. More than 40 years' domestic and international experience in the wine industry, including time spent with Evans & Tate, The Australian Wine Research Institute, BRL Hardy's Domaine de la Baume, Abbotts SARL and most recently 15 years with E. & J. Gallo based firstly in Europe and then in California with exposure to winemaking in Italy, Spain, Germany, South Africa, California, Argentina and New Zealand, and responsibility for delivery of significant cross-functional projects in large-scale and boutique-scale wine production in diverse cultural settings.
Special Responsibilities: Mr Sneyd is a member of the Personnel committee.

Mr Mark R. Watson, Non-executive director (to 31 December 2020)
Qualifications: BEc, MBA, FCA, RITP, MAICD
Experience: Director of SRG Partners, having previously held a range of senior management and finance roles including Chief Executive Officer of Radiology SA and Water Utilities Australia, and Chief Financial Officer of Wirra Wirra.
Special Responsibilities: Mr Watson was the Chair of the Audit committee.

Mr Marcus Y. Woods, Non-executive director (to 14 March 2021)
Qualifications: BAppSc (Vit), MBA
Experience: Operations Director at Pernod Ricard Winemakers. Over 20 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 was a member of the Personnel committee and the Audit committee.

Ms Corrina N. Wright, Non-executive director (from 1 January 2021)
Qualifications: BCom, BAgSc (Oen), MAICD
Experience: Owner and winemaker for Oliver's Taranga Vineyards and owner of Swell Brewing Co. Advisory Board member of the Australian Women in Wine Awards and previously a director of the Winemakers' Federation of Australia and McLaren Vale Grape, Wine & Tourism Association. An active wine show judge and wine writer, Chair of the Australian Alternative Varieties Wine Show. 2019 ASVO Winemaker of the Year.

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 $26 (2020: $22).

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 2021.

Dated at Urrbrae on this the 30th day of September 2021.

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

Mark P. Krstic
Managing Director

Declaration of independence

Declaration of independence by Paul Gosnold to the directors of the Australian Wine Research Institute Limited.

As lead auditor of The Australian Wine Research Institute Limited for the year ended 30 June 2021, I declare that, to the best of my knowledge and belief, there have been:

1. No contraventions of the auditor independence requirements of section 60-40 of the *Australian Charities and Not-for-profit 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, 30 September 2021

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 2021

	Note	**2021**	**2020**
Revenue from operating activities			
Wine Australia			
Investment agreement project funding		8,506,513	8,659,568
Investment agreement capital funding		321,346	27,126
Other project funding		83,559	154,385
Other capital funding		–	–
Capital specific grant funding		533,521	1,608,136
Other grant funding		1,219,700	1,043,436
Commercial services analytical and consulting income		4,162,573	4,382,865
Contract research and other commercial income		1,283,404	1,042,600
Other revenue		256,783	258,762
Total revenue		16,367,399	17,176,877
Other income	*2*	(200)	253,219
Expenses from operating activities			
Personnel expenses	*3*	10,797,335	10,804,561
Analytical and project operating expenses		2,951,772	2,562,484
Infrastructure and general services expenses		1,436,549	1,535,954
Depreciation and amortisation expense	*8, 9, 10*	1,280,423	1,079,297
Travel expenses		53,805	326,142
Total expenses		16,519,884	16,308,438
Results from operating activities		(152,685)	1,121,658
Finance income		448,990	423,464
Profit/(loss) for the period		296,305	1,545,122
Other comprehensive income			
Items that will not be reclassified subsequently to profit or loss			
Gain/(loss) on revaluation of financial assets at fair value through other comprehensive income		1,099,063	(420,240)
Total comprehensive income for the period		1,395,368	1,124,882

The notes on pages 63 to 70 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 2021

	Retained earnings	Co-investment reserve	Strategic IT investment reserve	Financial assets at fair value through OCI reserve	Total equity
Balance at 1 July 2019	13,061,062	714,529	209,204	724,496	14,709,291
Total comprehensive income for the period					
Profit or loss	1,545,122	–	–	–	1,545,122
Other comprehensive income					
Realised gain (loss) on revaluation of financial assets at fair value through other comprehensive income	–	–	–	(105,669)	(105,669)
Unrealised gain (loss) on revaluation of financial assets at fair value through other comprehensive income	–	–	–	(314,571)	(314,571)
Total other comprehensive income	–	–	–	(420,240)	(420,240)
Total comprehensive income for the period	1,545,122	–	–	(420,240)	1,124,882
Transfers between retained earnings and other reserves					
Transfers to (from) reserves	–	(48,133)	(198,029)	105,669	(140,493)
Transfers to (from) retained earnings	140,493	–	–	–	140,493
Balance at 30 June 2020	14,746,677	666,396	11,175	409,925	15,834,173
Balance at 1 July 2020	14,746,677	666,396	11,175	409,925	15,834,173
Total comprehensive income for the period					
Profit or loss	296,305	–	–	–	296,305
Other comprehensive income					
Realised gain (loss) on revaluation of financial assets at fair value through other comprehensive income	–	–	–	(38,323)	(38,323)
Unrealised gain (loss) on revaluation of financial assets at fair value through other comprehensive income	–	–	–	1,137,386	1,137,386
Total other comprehensive income	–	–	–	1,099,063	1,099,063
Total comprehensive income for the period	296,305	–	–	1,099,063	1,395,368
Transfers between retained earnings and other reserves					
Transfers to (from) reserves	–	(20,000)	–	38,323	18,323
Transfers to (from) retained earnings	(18,323)	–	–	–	(18,323)
Balance at 30 June 2021	15,024,659	646,396	11,175	1,547,311	17,229,541

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 63 to 70 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 2021

	Note	2021	2020
Assets			
Cash and cash equivalents	*4*	3,467,357	3,694,044
Term deposits	*5*	–	–
Trade and other receivables	*6*	1,327,778	1,048,265
Inventories	*7*	95,341	143,595
Prepayments		310,958	293,607
Total current assets		5,201,434	5,179,511
Financial assets at fair value through OCI	*5*	11,204,064	9,599,301
Property, plant and equipment	*8*	4,099,986	3,759,307
Intangible assets	*9*	231,424	236,040
Right of use assets	*10*	3,539,261	3,742,599
Total non-current assets		19,074,735	17,337,247
Total assets		24,276,169	22,516,758
Liabilities			
Payables and accruals	*11*	2,828,600	3,427,812
Contract liability	*12*	2,167,630	1,337,547
Provisions	*13*	1,838,410	1,725,599
Total current liabilities		6,834,640	6,490,958
Provisions	*13*	211,988	191,627
Total non-current liabilities		211,988	191,627
Total liabilities		7,046,628	6,682,585
Net assets		17,229,541	15,834,173
Equity			
Retained earnings		15,024,659	14,746,677
Co-investment reserve		646,396	666,396
Strategic IT investment reserve		11,175	11,175
Fair value reserve		1,547,311	409,925
Total equity		17,229,541	15,834,173

The notes on pages 63 to 70 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 2021

	Note	2021	2020
Cash flows from operating activities			
Cash receipts from project grants and other income		15,723,532	15,823,546
Cash paid to suppliers and employees		(15,974,672)	(15,028,597)
Net cash from operating activities		(251,140)	794,949
Cash flows from investing activities			
Cash receipts from capital specific funding		1,172,008	1,635,262
Interest received		152,163	220,157
Dividends and imputation credits received		293,852	259,297
Proceeds from sale of property, plant and equipment		–	44,538
Acquisition of property, plant, equipment and intangibles		(1,053,984)	(2,324,501)
(Acquisition)/proceeds from disposal of term deposits		–	1,600,000
Acquisition of financial assets		(489,080)	(498,798)
Payment of transaction costs related to financial investments		(50,505)	(49,636)
Net cash used in investing activities		24,454	886,319
Net increase (decrease) in cash and cash equivalents		(226,686)	1,681,268
Cash and cash equivalents at 1 July		3,694,043	2,012,775
Cash and cash equivalents at 30 June	*4*	3,467,357	3,694,043

The notes on pages 63 to 70 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*, registered as a charity under the *Australian Charities and Not-for-profits Commission Act 2012* (ACNC Act) and endorsed by the Australian Tax Office (ATO) as a Deductible Gift Recipient (DGR) organisation under the general DGR category of 'Approved Research Institute'. 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 30th day of September 2021.

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 (note 9), right of use assets including its interest in the WIC building (note 10) and provisions for employee entitlements (note 13) 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.

(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 Company 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 Company 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 Company'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

Lease liabilities
A lease liability is recognised at the commencement date of a lease. The lease liability is initially recognised at the present value of the lease payments to be made over the term of the lease, discounted using the interest rate implicit in the lease or, if that rate cannot be readily determined, the entity's incremental borrowing rate. Lease payments comprise of fixed payments less any lease incentives receivable, variable lease payments that depend on an index or a rate, amounts expected to be paid under residual value guarantees, exercise price of a purchase option when the exercise of the option is reasonably certain to occur, and any anticipated termination penalties. The variable lease payments that do not depend on an index or a rate are expensed in the period in which they are incurred.

Lease liabilities are measured at amortised cost using the effective interest method. The carrying amounts are remeasured if there is a change in the following: future lease payments arising from a change in an index or a rate used; residual guarantee; lease term; certainty of a purchase option and termination penalties. When a lease liability is remeasured, an adjustment is made to the corresponding right-of use asset, or to profit or loss if the carrying amount of the right-of-use asset is fully written down.

(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 recognition

The Company recognises revenue as follows:

(i) Revenue from contracts with customers
Revenue is recognised at an amount that reflects the consideration to which the Company is expected to be entitled in exchange for transferring goods or services to a customer. For each contract with a customer, the Company: identifies the contract with a customer; identifies the performance obligations in the contract; determines the transaction price which takes into account estimates of variable consideration and the time value of money; allocates the transaction price to the separate performance obligations on the basis of the relative stand-alone selling price of each distinct good or service to be delivered; and recognises revenue when or as each performance obligation is satisfied in a manner that depicts the transfer to the customer of the goods or services promised.

(ii) Donations
Donations are assessed to determine whether they carry sufficiently specific performance obligations and meet other criteria for recognition in accordance with AASB 15 *Revenue from Contracts with Customers*, where this is not the case donations are recognised on receipt in accordance with AASB 1058 *Income of Not-for-Profit Entities*.

(iii) Grants
Grant revenue is recognised in profit or loss when the Company satisfies the performance obligations stated within the funding agreements.

If conditions are attached to the grant which must be satisfied before the Company is eligible to retain the contribution, the grant will be recognised in the statement of financial position as a liability until those conditions are satisfied.

(iv) 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.

(v) Other revenue

Other revenue is recognised when it is received or when the right to receive payment is established.

(j) 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.

(k) 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.

(l) Right of use assets

A right of use asset is recognised at the commencement date of a lease. The right of use asset is measured at cost, which comprises the initial amount of the lease liability, adjusted for, as applicable, any lease payments made at or before the commencement date net of any lease incentives received, any initial direct costs incurred, and, except where included in the cost of inventories, an estimate of costs expected to be incurred for dismantling and removing the underlying asset, and restoring the site or asset.

Right of use assets are depreciated on a straight-line basis over the unexpired period of the lease or the estimated useful life of the asset, whichever is the shorter. Where the Company expects to obtain ownership of the leased asset at the end of the lease term, the depreciation is over its estimated useful life. Right of use assets are subject to impairment or adjusted for any remeasurement of lease liabilities.

The Company has elected not to recognise a right of use asset and corresponding lease liability for short-term leases with terms of 12 months or less and leases of low-value assets. Lease payments on these assets are expensed to profit or loss as incurred.

2. Other income

	2021	2020
Net gain/(loss) on sale of property, plant and equipment	(200)	14,474
Forgiveness of liabilities	–	238,745
	(200)	253,219

3. Personnel expenses

	2021	2020
Wages and salaries	9,423,732	9,414,458
Other associated personnel expenses	489,875	526,786
Contributions to defined contribution plans	883,728	863,317
	10,797,335	10,804,561

4. Cash and cash equivalents

	2021	2020
Cash on hand	133	500
Bank deposits at-call	3,467,224	3,693,544
Cash and cash equivalents in the statement of cash flows	3,467,357	3,694,044

5. Other investments

	2021	2020
Current		
Term deposits	–	–
Non-current		
Financial assets at fair value through OCI, comprising listed investments at fair value in:		
Interest rate securities	5,258,128	5,095,152
Equity securities	5,945,936	4,504,149
	11,204,064	9,599,301

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. Equity securities include direct shareholdings, exchange traded funds and managed funds.

6. Trade and other receivables

	2021	2020
Trade receivables due from those other than related parties	868,906	773,019
Trade receivables due from related parties	15,132	11,345
Other receivables	443,740	263,901
	1,327,778	1,048,265

Trade receivables are shown net of expected credit losses amounting to $30,852 (2020: $22,830) 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:

	2021	2020
Balance at 1 July	22,830	23,313
Payments received in relation to previous expected credit loss balances	(1,937)	(2,674)
Expected credit loss for the year	17,991	51,594
Written off during the year	(8,032)	(49,403)
Balance at 30 June	30,852	22,830

7. Inventories

	2021	2020
Course materials on hand – wine	88,341	105,978
Contingency supply of laboratory consumables	7,000	37,617
	95,341	143,595

8. Property, plant and equipment

	Plant and machinery	Office furniture and IT	Laboratory equipment	Capital WIP	Total
Cost					
Balance at 1 July 2020	675,187	1,173,543	12,073,231	198,726	14,120,687
Additions	6,400	112,865	752,186	399,289	1,270,740
Transfers	–	–	198,726	(198,726)	–
Disposals	–	(103,980)	(22,495)	–	(126,475)
Balance at 30 June 2021	681,587	1,182,428	13,001,648	399,289	15,264,952
Depreciation and impairment losses					
Balance at 1 July 2020	489,727	916,266	8,955,387	–	10,361,380
Depreciation charge for the year	59,599	106,264	763,998	–	929,861
Transfers	–	–	–	–	–
Disposals	–	(103,780)	(22,495)	–	(126,275)
Balance at 30 June 2021	549,326	918,750	9,696,890	–	11,164,966
Carrying amounts					
at 1 July 2020	185,460	257,277	3,117,844	198,726	3,759,307
at 30 June 2021	132,261	263,678	3,304,758	399,289	4,099,986

9. Intangible assets

	Computer software	Intangible assets under development	Total
Cost			
Balance at 1 July 2020	735,954	–	735,954
Additions	11,532	131,075	142,607
Balance at 30 June 2021	747,486	131,075	878,561
Amortisation and impairment losses			
Balance at 1 July 2020	499,914	–	499,914
Amortisation charge for the year	147,223	–	147,223
Balance at 30 June 2021	647,137	–	647,137
Carrying amounts			
at 1 July 2020	236,040	–	236,040
at 30 June 2021	100,349	131,075	231,424

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.

Intangible assets under development at 30 June 2021 represent expenditure towards the development of computer software which as of that date is not classified as ready for use.

10. Right of use assets

	2021	2020
Buildings (WIC)–right of use		
Cost		
Balance at 1 July	6,100,140	–
Recognition as right of use asset	–	6,100,140
Balance at 30 June	6,100,140	6,100,140
Depreciation and impairment losses		
Balance at 1 July	2,357,541	–
Recognition as right of use asset	–	2,154,203
Depreciation charge for the year	203,338	203,338
Balance at 30 June	2,560,879	2,357,541
Carrying amount	3,539,261	3,742,599

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 depreciated over a period of 30 years from the date of practical completion (26 November 2008).

11. Payables and accruals

	2021	2020
Current		
Trade payables due to those other than related parties	266,245	1,531,596
Trade payables due to related parties	–	–
PAYG and GST	379,472	273,457
Non-trade payables and accrued expenses	2,182,883	1,622,759
	2,828,600	3,427,812

12. Contract liability

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 2021 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.

The unexpended investment agreement funds for the current year totalled $317,141 (2020: none), relating only to a component of funding specifically to be applied towards capital equipment purchases. The unexpended funds from other WA contracts for the current year totalled $75,238 (2020: none).

During the year no unspent prior years' funds previously approved by WA for retention by the Company were utilised for agreed purposes (2020: $41,694). During the year no unspent prior years' funds relating to WA projects were returned to WA (2020: none).

	2021	2020
Unexpended funds carried forward to satisfy future performance obligations		
WA current year's investment agreement funding unexpended	317,141	–
WA current year's other contract funding unexpended	75,238	–
WA prior years' funding unexpended	–	–
	392,379	–
Income received in advance	1,775,251	1,337,547
	2,167,630	1,337,547

13. Provisions

	2021	2020
Current		
Employee entitlements	1,838,410	1,725,599
Non-current		
Employee entitlements	211,988	191,627
Number of employees (full-time equivalents)	106.4	103.9

14. Operating leases

Leases as lessee

Non-cancellable operating lease rentals are payable as follows:

	2021	2020
Within one year	3,432	3,432
One year or later and no later than five years	2,574	6,006
Later than five years	–	–
	6,006	9,438

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

During the year ended 30 June 2021 an amount of $3,432 was recognised as an expense in respect of operating leases (2020: $3,432).

Leases as lessor

The Company leases out part of its interest in the WIC building (refer note 10) to the Australian Wine Industry Technical Conference Incorporated. Associated lease payments are included within the transactions with related parties disclosed within note 16. The future minimum lease payments under non-cancellable leases are receivable as follows:

	2021	2020
Within one year	8,000	8,000
One year or later and no later than five years	32,000	32,000
Later than five years	1,333	9,333
	41,333	49,333

During the year ended 30 June 2021 an amount of $8,679 was recognised as rental income (2020: $8,602).

15. Capital commitments

	2021	2020
Property, plant and equipment		
Contracted but not provided for and payable		
Within one year	7,960	502,834
One year or later and no later than five years	–	–
Later than five years	–	–
	7,960	502,834
Computer software development		
Contracted but not provided for and payable		
Within one year	63,900	95,300
One year or later and no later than five years	–	–
Later than five years	–	–
	63,900	95,300

16. 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:

	2021	2020
Total remuneration	1,757,237	1,823,890

During the year non-executive directors became entitled to compensation totalling $93,003 (2020: $91,750). A number of directors voluntarily elected not to receive $59,157 of this entitlement (2020: $58,500), instead redirecting such amounts to support otherwise unfunded activities of the Company including individual and group professional development for AWRI staff, and the providision of 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
Oenologie Requin Pty Ltd (trading as Bekkers Wine)
Oliver's Taranga Vineyards
Swell Brewing Co.
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	
	2021	2020	2021	2020
Services received from related parties	2,082	54,153	–	–
Services provided to related parties	106,525	251,490	15,132	11,345

17. Contingencies

In the opinion of the Directors, there were no material or significant contingent liabilities at 30 June 2021 (2020: none).

18. Subsequent events

In June 2021 the Company received notice from its principal funding provider, Wine Australia, that it was exercising its right to terminate without cause the investment agreement between itself and the Company effective from 30 June 2022. At this time Wine Australia also expressed its intention to work together with the Company in good faith to negotiate a replacement long-term agreement to commence 1 July 2022, and further that this replacement agreement was to be in place by no later than December 2021. 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.

19. 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 $26 (2020: $22).

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 2021 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 Rose

Louisa E. Rose
Chair

Mark P. Krstic
Managing Director

Dated at Urrbrae on this the 30th day of September 2021.

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 2021, 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:

Giving a true and fair view of the registered entity's financial position as at 30 June 2021 and of its financial performance for the year then ended; and

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

(i) Giving a true and fair view of the registered entity's financial position as at 30 June 2021 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 (including Independence Standards)* (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 information included in The Australian Wine Research Institute Limited's annual report, but does not include the financial report and our auditor's report thereon.

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, 5 October 2021

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 2021; and
(ii) the statements of financial position give a true and fair view of each Trust's state of affairs as at 30 June 2021.

(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 Rose

Louisa E. Rose
Chair

Dated at Urrbrae on this the 30th day of September 2021.

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 2021	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**
Income								
Investments	4,642	5,785	3,020	4,016	3,096	3,962	3,655	4,514
Donations and other income	–	–	–	–	–	–	–	–
Total income	4,642	5,785	3,020	4,016	3,096	3,962	3,655	4,514
Expenses								
Investment management expenses	566	723	488	486	506	508	447	569
Contribution towards Library Management System	–	4,192	–	–	–	–	–	–
Sponsorship of 17th Australian Wine Industry Technical Conference	–	–	–	10,000	–	–	–	7,000
Total expenses	566	4,915	488	10,486	506	508	447	7,569
Profit/(loss) from ordinary activities	4,076	870	2,532	(6,470)	2,590	3,454	3,207	(3,055)
Other comprehensive income								
Items that will not be reclassified subsequently to profit or loss:								
Gain (loss) on revaluation of financial assets at fair value through other comprehensive income	10,146	(5,768)	6,194	(3,450)	6,922	(3,711)	7,994	(4,416)
Total comprehensive income for the period	14,222	(4,898)	8,726	(9,920)	9,512	(257)	11,201	(7,471)
Statements of financial position								
As at 30 June 2021	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**
Assets								
Cash at bank	2,527	2,312	1,603	1,550	1,885	6,728	1,981	1,872
Investments	–	–	–	–	–	–	–	–
Receivables	1,404	1,499	905	996	932	973	1,103	1,169
Total current assets	3,931	3,811	2,508	2,546	2,817	7,701	3,083	3,042
Investments	145,408	131,306	93,873	85,109	100,942	86,545	113,844	102,683
Total non-current assets	145,408	131,306	93,873	85,109	100,942	86,545	113,844	102,683
Total assets	149,339	135,117	96,381	87,655	103,759	94,246	116,927	105,725
Liabilities								
Committed funding contribution	–	–	–	–	–	–	–	–
Total current liabilities	–	–	–	–	–	–	–	–
Net assets	149,339	135,117	96,381	87,655	103,759	94,246	116,927	105,725
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	120,670	120,229	61,608	67,805	73,034	69,967	104,442	107,721
Profit/(loss) for the year	4,076	870	2,532	(6,470)	2,590	3,454	3,207	(3,055)
Transfers to (from) accumulated surplus	(448)	(429)	(251)	273	(253)	(388)	(313)	(224)
Closing balance	124,298	120,670	63,889	61,608	75,371	73,034	107,337	104,442
Financial assets at fair value through other comprehensive income reserve								
Opening balance	1,662	7,002	997	4,720	1,212	4,536	1,233	5,426
Gain (loss) on revaluation of financial assets at fair value through other comprehensive income	10,146	(5,769)	6,194	(3,450)	6,923	(3,712)	7,994	(4,416)
Transfers to (from) reserve	448	429	251	(273)	253	388	313	224
Closing balance	12,256	1,662	7,442	997	8,388	1,212	9,539	1,233
Total trust funds	149,339	135,117	96,381	87,655	103,759	94,246	116,927	105,725

APPENDIX 1

External presentations

Staff	Title of presentation	Presented to and where	Date
M.L. Longbottom	Sustainable Winegrowing Australia update	Treasury Wine Estates Grower Liaison Officer meeting (virtual)	2 Jul 2020
R. Gawel	How does dissolved carbon dioxide affect the taste and texture of still white and red wine?	AWRI webinar	9 Jul 2020
P.W. Godden, M.G. Holdstock, J.A. Gledhill	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Stanthorpe, Qld (virtual)	22 Jul 2020
M.L. Longbottom	Sustainable Winegrowing Australia update	McLaren Vale Sustainable Winegrowing Australia workshop, McLaren Vale, SA	23 Jul 2020
J.A. Culbert	Tackling smoke taint head on: winery remediation options for smoke-affected juice and wine	AWRI webinar	
S.J. Dillon	Shipwrecked beer yeast	The Royal Australian Chemical Institute – Winter is brewing: the chemistry of brewing (virtual)	
S.A. Schmidt	Glutathione: what is it and why is it in my wine?	AWRI webinar	30 Jul 2020
M.L. Longbottom	Sustainable Winegrowing Australia update		6 Aug 2020
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Mudgee, NSW (virtual)	
C.A. Simos	Smoke taint emergency response	Minister Basham visit, Urrbrae, SA	
E.N. Wilkes	Smoke testing 2020		
M.L. Longbottom	Supporting vineyard fire recovery 2020		
M.J. Herderich	New R&D insights from the 2020 bushfire disaster		
I.L. Francis, D. Espinase Nandorfy, E.O. Bilogrevic	Smoke taint sensory evaluation in SA		
M.L. Longbottom	Sustainable Winegrowing Rutherglen	Winemakers of Rutherglen Special General Meeting (virtual)	11 Aug 2020
S. Nordestgaard	Autonomous robots and electric tractors	AWRI webinar	20 Aug 2020
M.L. Longbottom	Sustainable Winegrowing Australia update	South Australian Wine Industry Association, Adelaide, SA	24 Aug 2020
M.J. Herderich	Managing vintage during COVID	Hochschule Geisenheim University seminar (virtual)	27 Aug 2020
D. Espinase Nandorfy	The perceptual interactions of wine flavour compounds	Deakin University School of Exercise and Nutrition (virtual)	28 Aug 2020
P.W. Godden	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Canberra, ACT (virtual)	10 Sep 2020
M.L. Longbottom, M. Coles	Sustainable Winegrowing Australia update	Pernod Ricard Wines Grower Liaison Officer meeting (virtual)	
P.W. Godden	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Orange, NSW (virtual)	16 Sep 2020
M. Essling	Chemical application trends in SA Central vineyards and threats to chemical access	SA Central Viti Expo, Longview Vineyards, Adelaide Hills, SA	22 Sep 2020

Staff	Title of presentation	Presented to and where	Date
T.M. Parker	Smoke taint research: lessons from Cudlee Creek	SA Central Viti Expo, Longview Vineyards, Adelaide Hills, SA	23 Sep 2020
M.L. Longbottom	Sustainable Winegrowing Australia as a tool for greater vineyard resilience	SA Central Viti Expo, Longview Vineyards, Adelaide Hills, SA	23 Sep 2020
S.A. Schmidt	Characterisation of genomic variation in grapevine clones	BAG Alliance meeting (virtual)	24 Sep 2020
A.M. Mierczynszka-Vasilev	Protein and tartrate stabilisation of wines	BAG Alliance meeting (virtual)	24 Sep 2020
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Hunter Valley, NSW (virtual)	25 Sep 2020
K.A. Bindon	Water addition to must: when to use it and how much?	AWRI webinar	1 Oct 2020
K.A. Bindon	Using maceration techniques to tailor red wine styles	Oenology webinar, Texas A&M University, USA	2 Oct 2020
E.N. Wilkes	AWRI responses to meeting ACCC recommendations for wine-grape pricing	Australian Grape & Wine Code of Practice webinar	8 Oct 2020
S.A. Schmidt	Modulating red wine composition through aeration during fermentation	ASVO seminar (virtual)	20 Oct 2020
K.A. Bindon	Balancing the extraction and loss of phenolics	ASVO seminar (virtual)	20 Oct 2020
M. Essling	Developing confidence in integrated pest management instead of chemical options to control pest and disease	AWRI roadshow seminar, Langhorne Creek, SA	22 Oct 2020
M. Essling	Can weeds be controlled without synthetic chemicals?	AWRI roadshow seminar, Langhorne Creek, SA	22 Oct 2020
G.D. Cowey	Learnings from 2020 from the AWRI	AWRI smoke taint seminar, Rutherglen, Vic (virtual)	26 Oct 2020
T.M. Parker	Insight into the effects of early-season smoke exposure of vineyards and grapes	AWRI smoke taint seminar, Rutherglen, Vic (virtual)	26 Oct 2020
J.A. Culbert	Winemaking mitigation strategies for smoke taint	AWRI smoke taint seminar, Rutherglen, Vic (virtual)	26 Oct 2020
C.A. Simos	Preparing for vintage 2021	AWRI smoke taint seminar, Rutherglen, Vic (virtual)	26 Oct 2020
G.D. Cowey	Learnings from 2020 from the AWRI	AWRI smoke taint seminar, Yarra Valley, Vic (virtual)	27 Oct 2020
M.J. Herderich	Insight into the effects of early-season smoke exposure of vineyards and grapes	AWRI smoke taint seminar, Yarra Valley, Vic (virtual)	27 Oct 2020
J.A. Culbert	Winemaking mitigation strategies for smoke taint	AWRI smoke taint seminar, Yarra Valley, Vic (virtual)	27 Oct 2020
C.A. Simos	Preparing for vintage 2021	AWRI smoke taint seminar, Yarra Valley, Vic (virtual)	27 Oct 2020
D. Espinase Nandorfy	The perception of mouthfeel in wine: a sensory perspective and clues from neurophysiology	ASVO seminar (virtual)	27 Oct 2020
R. Gawel	White wine texture	ASVO seminar (virtual)	27 Oct 2020
M.G. Holdstock	Regional snapshot	AWRI roadshow seminar, Coonawarra, SA	28 Oct 2020
S. Nordestgaard	Trends in Australian grapegrowing practices	AWRI roadshow seminar, Coonawarra, SA	28 Oct 2020
K.A. Bindon	How to improve fruit set in cool climates	AWRI roadshow seminar, Coonawarra, SA	28 Oct 2020
S. Nordestgaard	Flotation technology in the wine industry and other sectors	AWRI roadshow seminar, Coonawarra, SA	28 Oct 2020
K.A. Bindon	Using maceration techniques to tailor red wine styles	AWRI roadshow seminar, Coonawarra, SA	28 Oct 2020
G.D. Cowey	Learnings from 2020 from the AWRI	AWRI smoke taint seminar, Gippsland, Vic (virtual)	28 Oct 2020
W. Jiang	Insight into the effects of early-season smoke exposure of vineyards and grapes	AWRI smoke taint seminar, Gippsland, Vic (virtual)	28 Oct 2020
J.A. Culbert	Winemaking mitigation strategies for smoke taint	AWRI smoke taint seminar, Gippsland, Vic (virtual)	28 Oct 2020
C.A. Simos	Preparing for vintage 2021	AWRI smoke taint seminar, Gippsland, Vic (virtual)	28 Oct 2020
I.L. Francis	Using consumer sensory data	Accolade Wines Technical Conference, Tanunda, SA	28 Oct 2020
P.W. Godden	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Accolade Wines, McLaren Vale, SA	29 Oct 2020

Staff	Title of presentation	Presented to and where	Date
P.W. Godden	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Treasury Wine Estates, Barossa Valley, SA	30 Oct 2020
	Tasting and presentation on Australian and Italian Nebbiolo wines	Pernod Ricard Winemakers, Barossa Valley, SA	3 Nov 2020
M.P. Krstic	Vision for the AWRI	Wine Australia Research, Development and Adoption Committee, Adelaide, SA	4 Nov 2020
M.L. Longbottom	Sustainable Winegrowing Rutherglen	Wines of Rutherglen members (virtual)	5 Nov 2020
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Tasmania (virtual)	11 Nov 2020
G.D. Cowey	Learnings from 2020 from the AWRI	AWRI smoke taint seminar, King Valley, Vic (virtual)	
W. Jiang	Insight into the effects of early-season smoke exposure of vineyards and grapes		
J.A. Culbert	Winemaking mitigation strategies for smoke taint		
C.A. Simos	Preparing for vintage 2021		
T.E. Siebert	Did someone light a match? 'Struck match'/'struck flint' and other fun sulfur compounds in Chardonnay	Wine Tasmania: Annual Winemaker Symposium, Hobart, Tas (virtual)	
E.N. Wilkes	Integrating science and law	Australasian Wine Law Association, Clare Valley, SA	14 Nov 2020
K.A. Bindon	Regional discrimination of Shiraz using targeted and non-targeted analytical approaches	XIIIth International Terroir Congress (virtual)	17 Nov 2020
M.J. Herderich	Wildfires and smoke taint risk: experiences from the 2019/2020 Australian vintage	Vineyard Technical Group, Sonoma County, USA (virtual)	18 Nov 2020
M.G. Holdstock	Regional snapshot	AWRI roadshow seminar, Griffith, NSW (virtual)	19 Nov 2020
A.R. Borneman	Bringing science to 'wild' wine		
K.A. Bindon	Demystifying grape quality		
J.L. Hixson	Increasing wine flavour with glycoside additions		
M.Z. Bekker	Managing 'reductive' aromas in wine		
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Griffith, NSW	
S.A. Schmidt	Aerating ferments: why aeration is useful and how you can do it	AWRI webinar	24 Nov 2020
M. Essling	Developing confidence in integrated pest management instead of chemical options to control pest and disease	AWRI roadshow seminar, Margaret River, WA (virtual)	25 Nov 2020
S. Nordestgaard	Trends in Australian grapegrowing practices		
M.J Herderich, T.M. Parker, W. Jiang	Out of the smoke: experiences from the 2019/2020 Australian bushfire season	Webinar for grapegrowers and winemakers from the Adelaide Hills wine region	26 Nov 2020
E.N. Wilkes	Measuring Baumé and Brix and understanding their relationship with final alcohol concentration	AWRI webinar	3 Dec 2020
S. Nordestgaard	Optimising your grape press		10 Dec 2020
T.M. Parker	Out of the smoke: experiences from the 2019/2020 Australian bushfire season – early-season smoke exposure from the Cudlee Creek fire	Collaborative partners of Adelaide Hills smoke research project, Adelaide Hills landholders and winemakers, Wine Australia and PIRSA, Urrbrae, SA	28 Jan 2021
C.A. Simos	Smoke taint Q&A	Smoke taint Q&A session, Coonawarra, SA	29 Jan 2021
P.O. Williamson	Perception of smoke taint and best sensory practices	Smoke taint sensory panel workshop, Bendigo, Vic	1 Feb 2021
	Screening of tasters' sensitivity to smoke taint glycosides		
	Familiarisation with smoke taint compounds		
	Sensory exercise – real smoke-tainted samples		
	Sensory exercise – Pinot Noir winemaking techniques		

Staff	Title of presentation	Presented to and where	Date
P.O. Williamson	Perception of smoke taint and best sensory practices	Smoke taint sensory panel workshop, Strathbogie Ranges, Vic	2 Feb 2021
P.O. Williamson	Screening of tasters' sensitivity to smoke taint glycosides	Smoke taint sensory panel workshop, Strathbogie Ranges, Vic	2 Feb 2021
P.O. Williamson	Familiarisation with smoke taint compounds	Smoke taint sensory panel workshop, Strathbogie Ranges, Vic	2 Feb 2021
P.O. Williamson	Sensory exercise – real smoke-tainted samples	Smoke taint sensory panel workshop, Strathbogie Ranges, Vic	2 Feb 2021
P.O. Williamson	Sensory exercise – Pinot Noir winemaking techniques	Smoke taint sensory panel workshop, Strathbogie Ranges, Vic	2 Feb 2021
M. G. Holdstock	Regional snapshot	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
R.A. Dixon	Scale and mealybug – what can I do to control these sap-sucking insects?	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
R.A. Dixon	Understanding powdery mildew and strategies to help control the disease	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
M.Z. Bekker	Managing 'reductive' aromas in wine	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
M. G. Holdstock	*Brettanomyces* – causes and management strategies	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
M.Z. Bekker	Copper – the good, the bad and the ugly	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
M.Z. Bekker	Managing 'reductive' aromas in wine	AWRI roadshow seminar, Stanthorpe, Qld (virtual)	2 Feb 2021
D. Espinase Nandorfy	Smoke taint sensory evaluation: indicative screening, familiarisation and practice rating	Treasury Wine Estates, Barossa, SA	2 Feb 2021
P.O. Williamson	Perception of smoke taint and best sensory practices	Smoke taint sensory panel workshop, Milawa, Vic	3 Feb 2021
P.O. Williamson	Screening of tasters' sensitivity to smoke taint glycosides	Smoke taint sensory panel workshop, Milawa, Vic	3 Feb 2021
P.O. Williamson	Familiarisation with smoke taint compounds	Smoke taint sensory panel workshop, Milawa, Vic	3 Feb 2021
P.O. Williamson	Sensory exercise – real smoke-tainted samples	Smoke taint sensory panel workshop, Milawa, Vic	3 Feb 2021
P.O. Williamson	Sensory exercise – Pinot Noir winemaking techniques	Smoke taint sensory panel workshop, Milawa, Vic	3 Feb 2021
P.O. Williamson	Perception of smoke taint and best sensory practices	Smoke taint sensory panel workshop, Yarra Valley, Vic	4 Feb 2021
P.O. Williamson	Screening of tasters' sensitivity to smoke taint glycosides	Smoke taint sensory panel workshop, Yarra Valley, Vic	4 Feb 2021
P.O. Williamson	Familiarisation with smoke taint compounds	Smoke taint sensory panel workshop, Yarra Valley, Vic	4 Feb 2021
P.O. Williamson	Sensory exercise – real smoke-tainted samples	Smoke taint sensory panel workshop, Yarra Valley, Vic	4 Feb 2021
P.O. Williamson	Sensory exercise – Pinot Noir winemaking techniques	Smoke taint sensory panel workshop, Yarra Valley, Vic	4 Feb 2021
P.O. Williamson	Perception of smoke taint and best sensory practices	Smoke taint sensory panel workshop, Mornington Peninsula, Vic	5 Feb 2021
P.O. Williamson	Screening of tasters' sensitivity to smoke taint glycosides	Smoke taint sensory panel workshop, Mornington Peninsula, Vic	5 Feb 2021
P.O. Williamson	Sensory exercise – real smoke-tainted samples	Smoke taint sensory panel workshop, Mornington Peninsula, Vic	5 Feb 2021
P.O. Williamson	Familiarisation with smoke taint compounds	Smoke taint sensory panel workshop, Mornington Peninsula, Vic	5 Feb 2021
P.O. Williamson	Sensory exercise – Pinot Noir winemaking techniques	Smoke taint sensory panel workshop, Mornington Peninsula, Vic	5 Feb 2021
M.G. Holdstock	Regional snapshot	AWRI roadshow seminar, Hobart, Tas (virtual)	9 Feb 2021
R.A. Dixon	How to improve fruit set in cool climates	AWRI roadshow seminar, Hobart, Tas (virtual)	9 Feb 2021
R.A. Dixon	Organic vs conventional practices compared – what's stopping you from going organic?	AWRI roadshow seminar, Hobart, Tas (virtual)	9 Feb 2021
K.A. Bindon	Using maceration techniques to tailor red wine styles	AWRI roadshow seminar, Hobart, Tas (virtual)	9 Feb 2021
R. Gawel	White wine texture: the interactive effects of phenolics, polysaccharides, acidity and alcohol	AWRI roadshow seminar, Hobart, Tas (virtual)	9 Feb 2021
M.G. Holdstock	Regional snapshot	AWRI roadshow seminar, Launceston, Tas (virtual)	10 Feb 2021
K.A. Bindon	Using maceration techniques to tailor red wine styles	AWRI roadshow seminar, Launceston, Tas (virtual)	10 Feb 2021
R.A. Dixon	How to improve fruit set in cool climates	AWRI roadshow seminar, Launceston, Tas (virtual)	10 Feb 2021
R. Gawel	White wine texture: the interactive effects of phenolics, polysaccharides, acidity and alcohol	AWRI roadshow seminar, Launceston, Tas (virtual)	10 Feb 2021
R.A. Dixon	Organic vs conventional practices compared – what's stopping you from going organic?	AWRI roadshow seminar, Launceston, Tas (virtual)	10 Feb 2021

Staff	Title of presentation	Presented to and where	Date
D. Espinase Nandorfy	'Does this wine's smell taste viscous?' – interactions of flavour compounds exciting smell, taste and oral touch in red wine and wine-like systems	15th NZOZ Sensory and Consumer Science Symposium (virtual)	11 Feb 2021
M.L. Longbottom	Sustainable Winegrowing Australia update	Australian Grape and Wine Regional Forum (virtual)	17 Feb 2021
K.A Bindon	Review of grape phenolics and effects of maceration techniques	Oregon, USA Wine Symposium (virtual)	19 Feb 2021
N. Scrimgeour	Red wine phenolics and the WineCloud	Delicato Wines, USA (virtual)	24 Feb 2021
M.P. Krstic	AWRI Annual Report update	Wines of WA Board meeting (virtual)	22 Apr 2021
A.R Borneman	The origin of Chardonnay clones with historical significance in Australia and California	AWRI webinar	29 Apr 2021
E.N. Wilkes	The strengths and weakness of various wine fingerprinting technologies to authenticate wine	Australian Grape & Wine seminar 'Australian Wine: Trade with China and opportunities for diversification', Adelaide, SA	4 May 2021
J.L. Hixson	Methods for predicting and assessing flavour evolution during white wine ageing	Weurman Flavour Research Symposium, Dijon, France (virtual)	5 May 2021
M.P. Krstic	AWRI Annual Report update	Queensland Wine Industry Association Board meeting (virtual)	10 May 2021
W.P. Pearson	Flavours, taints and faults	Advanced Wine Assessment Course (AWAC 51), Urrbrae, SA	
M.L. Longbottom	Sustainable Winegrowing Australia update	Hunter Valley sustainability and biosecurity event (virtual)	12 May 2021
M.G. Holdstock	Palate performance and statistical evaluation	Advanced Wine Assessment Course (AWAC 51), Urrbrae, SA	13 May 2021
W.P. Pearson	Flavours, taints and faults	Advanced Wine Assessment Course (AWAC 52), Urrbrae, SA	17 May 2021
M.J. Herderich	Advances in wine authenticity and provenance testing: a New World perspective	OENOVITI International Symposium 2021 'Challenges in viticulture and oenology: wine appellations, authenticity and innovation' (virtual)	19 May 2021
M.G. Holdstock	Palate performance and statistical evaluation	Advanced Wine Assessment Course (AWAC 52), Urrbrae, SA	20 May 2021
W.P. Pearson	Flavours, taints and faults	Advanced Wine Assessment Course (AWAC 53), Urrbrae, SA	24 May 2021
M.P. Krstic	National overview – impact of bushfires on the Australian wine sector in vintage 2020	National Wine Sector Bushfire Conference, Hahndorf, SA	25 May 2021
E.N. Wilkes	Smoke taint diagnostics: insights from the commercial laboratories		
D. Espinase Nandorfy	Smoke taint sensory evaluation: considerations to improve rigour and aid decision-making		
T.M. Parker	Pre-veraison smoke exposure: learnings from the 2019 Adelaide Hills fire event		
E.N. Wilkes	The importance of proficiency testing programs to ensure ease of trade in international markets	International Wine Technical Summit (virtual)	26 May 2021
M.P. Krstic	AWRI Annual Report update	Wine Tasmania Technical Committee (virtual)	
M.G. Holdstock	Palate performance and statistical evaluation	Advanced Wine Assessment Course (AWAC 53), Urrbrae, SA	27 May 2021
M.L. Longbottom	Sustainability in the Australian grape and wine sector	Australian Property Institute regional conference, McLaren Vale, SA	28 May 2021
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Great Southern, WA (virtual)	8 Jun 2021

Staff	Title of presentation	Presented to and where	Date
M.G. Holdstock	Evaluation of winemaking treatments in Australian Chardonnay	Chardonnay winemaking trial tasting, Pernod Ricard Winemakers, Barossa Valley, SA	15 Jun 2021
L.M. Pitcher	Sustainable Winegrowing Australia update	South Australian Wine Industry Association meeting, Adelaide, SA (virtual)	
D. Espinase Nandorfy	Interactions shaping the Shiraz wine tasting experience	Crush 2021 – the grape and wine science symposium, Adelaide, SA	16 Jun 2021
S. Nordestgaard	Ferment sensors – time to adopt?		
F.T. Watson	Automated NMR workflows for accurate metabolite quantitation		
A.G. Cordente	Modulation of 'fruity' thiol production by yeast during red wine fermentation		
W. Jiang	Phenolic glycosides in leaves as biomarkers for pre-veraison smoke exposure		
N.D.R Lloyd	Smoke taint: potential markers beyond volatile phenols and their glycosides?		
J. Hildebrandt	Understanding the chemical basis of 'jam' and 'raisin' character in red wine and grapes		
P.J. Costello	Early, transient acetaldehyde formation by *Saccharomyces cerevisiae* – a vital factor affecting SO_2 tolerance and malolactic fermentation performance of *Oenococcus oeni* during co-fermentation in Chardonnay		
C.A. Onetto	Transcriptomic analysis of *Oenococcus oeni* SO_2 stress response		
E.O. Bilogrevic	Using projective mapping based on choice to assess consumer response to alternative wine varieties		
A.M. Mierczynska-Vasilev	A new approach to achieve tartrate stabilisation of white wines		
A.L. Jouin	Evolution of crown procyanidins during winemaking and bottle ageing		
Y. Grebneva	Effect of pressing and fermentation on ageing potential of *Vitis vinifera* L. cv. Riesling		
K.C. Hirlam	Understanding variability of juice extraction methods for quality analysis		
W.P. Pearson	Low- and no-alcohol wine: insights and innovations	Sustainable Food Future Conference, Central Coast Campus, University of Newcastle, NSW	18 Jun 2021
M.L. Longbottom	Sustainability in the Australian grape and wine sector	Interwinery Analysis Group Seminar, West Lakes, SA	
G.D. Cowey	Smoke taint – prevention, mitigation, and amelioration		
T.M. Parker	Glycosides and their role in flavour release		
M.G. Holdstock	Flavours, taints and faults	Barossa Wine Assessment Training, Barossa Valley, SA	22 Jun 2021
	Palate performance and statistical evaluation		23 Jun 2021
M.L. Longbottom	Sustainability – global insights	Sustainability workshop, Margaret River, WA (virtual)	29 Jun 2021
L.M. Pitcher	Margaret River sustainability performance and targets		
M.L. Longbottom	Demonstrating functionality of the Sustainable Winegrowing Australia portal		
	Sustainability certification		
R.A. Dixon	Effective weed control at Vasse Felix: good decision-making and creative thinking		
M.L. Longbottom	Sheep and straw mulch for energy and water savings at Lake Moodemere Estate, Rutherglen		
	Sustainable Winegrowing Australia – McLaren Vale update	McLaren Vale regional season opening, McLaren Vale, SA	30 Jun 2021

APPENDIX 2

Events organised by AWRI staff

Staff	Title of workshop	Held	Date
M.G. Holdstock, E.-M. Panagis, F. Blefari, J. Scudds, P.W. Godden, J.A. Gledhill	Chardonnay winemaking trial tasting	Stanthorpe, Qld (virtual)	22 Jul 2020
M.L Longbottom, M. Coles, E.-M. Panagis, F. Blefari, J. Scudds	Australian Wine Industry Standard of Sustainable Practice training	Urrbrae, SA (virtual)	3 Aug 2020
M.P. Krstic, C.A. Simos, E.N. Wilkes, M.L. Longbottom, M.J. Herderich, I.L. Francis, D. Espinase Nandorfy, E. Bilogrevic	Minister Basham visit	Urrbrae, SA	6 Aug 2020
M. Holdstock, E.-M. Panagis, F. Blefari, J. Scudds, M.G. Holdstock	Chardonnay winemaking trial tasting	Mudgee, NSW (virtual)	
M.L Longbottom, M. Coles, E.-M. Panagis, F. Blefari, J. Scudds	Australian Wine Industry Standard of Sustainable Practice training	Urrbrae, SA (virtual)	19 Aug 2020
P.W. Godden, J. Scudds, F. Blefari	Chardonnay winemaking trial tasting	Canberra, ACT (virtual)	10 Sep 2020
P.W Godden, E.-M. Panagis, F. Blefari, J. Scudds		Orange, NSW (virtual)	16 Sep 2020
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari		Hunter Valley, SA (Virtual)	25 Sep 2020
M.L. Longbottom, E.-M. Panagis, F. Blefari, J. Scudds, M. Coles	Australian Wine Industry Standard of Sustainable Practice certification training	Urrbrae, SA (virtual)	7, 8 and 16 Oct 2020
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari, M. Essling	AWRI roadshow seminar	Langhorne Creek, SA	22 Oct 2020
C.A. Simos, E.-M. Panagis, F. Blefari, J. Scudds, G.D. Cowey, T.M. Parker, J.A. Culbert	AWRI smoke taint seminar	Rutherglen, Vic (virtual)	26 Oct 2020
C.A. Simos, E.-M. Panagis, F. Blefari, G.D. Cowey, M.J. Herderich, J.A. Culbert		Yarra Valley, Vic (virtual)	27 Oct 2020
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari, S. Nordestgaard, K.A. Bindon	AWRI roadshow seminar	Coonawarra, SA	28 Oct 2020
C.A. Simos, E.-M. Panagis, F. Blefari, G.D. Cowey, W. Jiang, J.A. Culbert, J. Scudds	AWRI smoke taint seminar	Gippsland, Vic (virtual)	
P.W. Godden, E.-M. Panagis, F. Blefari, J. Scudds	Chardonnay winemaking trial tasting, Accolade Wines	McLaren Vale, SA	29 Oct 2020
	Chardonnay winemaking trial tasting, Treasury Wine Estates	Barossa Valley, SA	30 Oct 2020
M.L. Longbottom, E.-M. Panagis, F. Blefari, J. Scudds, M. Coles, M.L. Longbottom	Australian Wine Industry Standard of Sustainable Practice certification training	Urrbrae, SA (virtual)	2, 3 and 6 Nov 2020
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari	Chardonnay winemaking trial tasting	Hobart, Tas (virtual)	11 Nov 2020
C.A. Simos, E.-M. Panagis, F. Blefari, J. Scudds, G.D. Cowey, W. Jiang, J.A. Culbert	AWRI smoke taint seminar	King Valley, Vic (virtual)	
M.G. Holdstock, E.-M. Panagis, F. Blefari, J. Scudds, A.R. Borneman, K.A. Bindon, J.L. Hixson, M.Z. Bekker	AWRI roadshow seminar	Griffith, NSW (virtual)	19 Nov 2020
M.G. Holdstock, E.-M. Panagis, J. Scudds, F. Blefari	Chardonnay winemaking trial tasting		
M.L. Longbottom, E.-M. Panagis, F. Blefari, J. Scudds, M. Coles, M.L. Longbottom	Australian Wine Industry Standard of Sustainable Practice certification training	Urrbrae, SA (virtual)	24, 26 and 30 Nov 2020
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari, M. Essling, S. Nordestgaard	AWRI roadshow seminar	Margaret River, WA (virtual)	25 Nov 2020

Staff	Title of workshop	Held	Date
M.L. Longbottom, M. Coles, E.-M. Panagis, F. Blefari, J. Scudds	Australian Wine Industry Standard of Sustainable Practice certification training	Urrbrae, SA (virtual)	12, 13 and 15 Jan 2021
		McLaren Vale, SA	21 Jan 2021
C.A. Simos, J. Scudds, E.-M. Panagis, F. Blefari	Smoke taint Q&A session	Coonawarra, SA	29 Jan 2021
C.A. Simos, P.O. Williamson, E.-M. Panagis, F. Blefari, J. Scudds	Smoke taint sensory panel workshop	Bendigo, Vic	1 Feb 2021
		Strathbogie Ranges, Vic	2 Feb 2021
M.G. Holdstock, R.A. Dixon, M.Z. Bekker, J. Scudds, E.-M. Panagis, F. Blefari	AWRI roadshow seminar	Stanthorpe, Qld (virtual)	
C.A. Simos, P.O. Williamson, E.-M. Panagis, F. Blefari, J. Scudds	Smoke taint sensory panel workshop	Milawa, Vic	3 Feb 2021
		Yarra Valley, Vic	4 Feb 2021
		Mornington Peninsula, Vic	5 Feb 2021
M.G. Holdstock, R.A. Dixon, K.A. Bindon, R. Gawel, J. Scudds, E.-M. Panagis, F. Blefari	AWRI roadshow seminar	Hobart, Tas (virtual)	9 Feb 2021
		Launceston, Tas (virtual)	10 Feb 2021
M.L. Longbottom, M. Coles, E.-M. Panagis, F. Blefari, J. Scudds	Australian Wine Industry Standard of Sustainable Practice certification training	Urrbrae, SA (virtual)	22, 23 and 25 Feb 2021
			22, 23 and 26 Feb 2021
M.L. Longbottom, L.M. Pitcher	Sustainability certification FAQ session	Urrbrae, SA (virtual)	12 Apr 2021
			13 Apr 2021
			14 Apr 2021
			20 Apr 2021
C.A. Simos, F. Blefari, B.H Cordingley, E.-M. Panagis, G.D. Cowey, J. Scudds, M.G Holdstock, P.W. Godden, W.P. Pearson	Advanced Wine Assessment Course (AWAC 51)	Urrbrae, SA	10-13 May 2021
	Advanced Wine Assessment Course (AWAC 52)		17-20 May 2021
	Advanced Wine Assessment Course (AWAC 53)		24-27 May 2021
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari	Chardonnay winemaking trial tasting	Great Southern, WA (virtual)	8 Jun 2021
M.L. Longbottom, L.M. Pitcher, J. Scudds, E.-M. Panagis, F. Blefari	Australian Wine Industry Standard of Sustainable Practice certification training	Orange, NSW (virtual)	9 Jun 2021
M.G. Holdstock, J. Scudds, E.-M. Panagis, F. Blefari	Chardonnay winemaking trial tasting, Pernod Ricard Winemakers	Barossa Valley, SA	15 Jun 2021
N.J. Burgan, C.A. Varela, M.Z Bekker, P. Boss (CSIRO), C. Bottcher (CSIRO), V. Pagay (University of Adelaide), D.L. Capone (University of Adelaide), I. Ismail (SARDI), P. Hayman (SARDI)	Crush 2021 – the grape and wine science symposium	Adelaide, SA	16 Jun 2021
C.A. Simos, J. Scudds, E.-M. Panagis, F. Blefari	Six of the best: alternative varieties from around the world (in conjunction with The University of Adelaide)	Urrbrae, SA (virtual)	
M.L. Longbottom, L.M. Pitcher, J. Scudds, E.-M. Panagis, F. Blefari	Australian Wine Industry Standard of Sustainable Practice certification training		21 Jun 2021
M.G. Holdstock, E.-M. Panagis, J. Scudds, F. Blefari	Barossa Wine Assessment Training	Barossa Valley, SA	22-23 Jun 2021
M.L. Longbottom, L.M. Pitcher, R.A. Dixon	Sustainability workshop	Margaret River, WA (virtual)	29 Jun 2021

APPENDIX 3

Posters

Authors	Title of poster	Presented at	Date
Y. Grebneva, M.J. Herderich, D. Rauhut[1], E.O Bilogrevic, J.L. Hixson	Shades of shading: chemical and sensory evaluation of Riesling grown under various shading techniques	Macrowine 2021 (virtual)	23-30 Jun 2021
Affiliations of non-AWRI authors: [1]Hochschule Geisenheim University			

APPENDIX 4

Teaching responsibilities (lectures) of AWRI staff

Institution	Subject number	Subject name	No. of lectures	Staff member
University of Adelaide	3046WT/7046WT	Fermentation technology	2	I.L. Francis
			1	E.N. Wilkes
	7038WT	Distillation and fortification	3	J.A. Gledhill
	3007WT/7010WT	Stabilisation and clarification	2	K.A. Bindon
			3	A.D. Coulter
			1	R. Gawel
	3500WT/7560WT	Grape and wine industry practice, policy and communication	1	M.L. Longbottom
			1	S.A. Schmidt
			1	J.L. Hixson
	2520WT	Microbiology and biotechnology	1	S.A. Schmidt
	CHEM2530	Environmental and analytical chemistry	2	J.A. Culbert
University of South Australia	FOSC 3009	Product development and food analysis	3	J.L. Hixson

APPENDIX 5

Student supervision responsibilities of AWRI staff

Student	Supervisors	Source of funds
PhD		
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
Yevgeniya Grebneva	M.J. Herderich, J.L. Hixson, M. Stoll[2], D. Rauhut[2]	Hochschule Geisenheim University, AWRI
Wes Pearson	I.L. Francis, J. Blackman[3], L. Schmidtke[3]	Wine Australia
Gail Gnoinski	S.A. Schmidt, D. Close[4], F.L. Kerslake[4]	University of Tasmania
Colleen Szeto	K.L. Wilkinson[5], V. Pagay[5], M.J. Herderich	ARC ITTC-2, University of Adelaide
Naomi Verdonk	K.L. Wilkinson[5], K. Pearce[1], R. Ristic[5], J.A. Culbert	University of Adelaide, Wine Australia
Yihe (Eva) Sui	K.L. Wilkinson[5], P.W. Godden	University of Adelaide
Wenyu (Wayne) Kang	S.E.P. Bastian[5], R. Muhlack[5], P.A. Smith[6], K.A. Bindon	University of Adelaide, Wine Australia
Andres Zhou Tsang	M. Gilliham[5], A.R. Borneman, M. Walker[5]	ARC ITTC-2, University of Adelaide
Qi Wu	S.D. Tyerman[5], N. Habili, F.E. Constable[7], A.R. Rinaldo	University of Adelaide, Wine Australia
Stephanie Angela	K.L. Wilkinson[5], K. Bindon, R. Muhlack[5], A. Mierczynszka-Vasilev	University of Adelaide
Damian Espinase Nandorfy	I.L. Francis, R. Keast[8], R. Shellie[8], J. Bekkers[9]	Wine Australia
Kamalpreet Kaur	F.E. Constable[7], B Rodoni[10], A.R. Rinaldo	Wine Australia, La Trobe University
Masters		
Justine Cohen	R. Nettle[11], C. Barnes[11], M.L. Longbottom	University of Melbourne

Affiliations: [1]University of South Australia, [2]Hochschule Geisenheim University, Germany, [3]Charles Sturt University, [4]University of Tasmania, [5]University of Adelaide, [6]Wine Australia, [7]Agriculture Victoria, [8]Deakin University, [9]The Australian National University, [10]La Trobe University, [11]University of Melbourne

APPENDIX 6

Media interviews

Date	Staff member	Discussed	Media
2 Jul 2020	K.A. Bindon	Cold stabilisation research	Jacquie van Santen, *Wine Australia RD&A news*
24 Jul 2020	M.G. Holdstock	Top tips for MLF	
27 Jul 2020	M.L. Longbottom	Sustainability in the Australian wine industry	Jackie MacDonald, *Selector*
29 Jul 2020	A.D. Coulter	Using microwaves to warm wine	Huon Hooke, *The Real Review*
5 Aug 2020	S.A. Schmidt	Origin of Chardonnay clone names	Jeni Port, wine writer
20 Aug 2020	M.P. Krstic	'Clean' wine	Claire Murphy/Melanie Tait, *Mamamia podcast 'The Quicky'*

Date	Staff member	Discussed	Media
18 Sep 2020	C.A. Simos	Smoke influence in the vineyard	Sean Sullivan, *Wine Enthusiast*
	E.N. Wilkes	Authenticity testing for wine	Russ Banham, freelance journalist
21 Sep 2020	M.P. Krstic	Bushfires and smoke taint in the USA	Andrew Selsky, *Associated Press*
28 Sep 2020		Mitigating smoke taint	Eddie Summerfield, *Nine Radio podcast*
30 Sep 2020		PhD industry journey	Tamara Agnew, *Podbean podcast*
	C.A. Simos	Smoke taint tool kit	Melissa Parker, *Drinks Trade Online*
1 Oct 2020		Smoke taint	
6 Oct 2020	M.P. Krstic		Isabella Pittaway, *ABC Country Hour*
9 Oct 2020		Sustainable Winegrowing Australia	Max Allen, wine writer
			Jane Faulkner, wine writer
21 Oct 2020			Max Allen, wine writer
27 Oct 2020	M.J. Herderich, M.L. Longbottom	Effects of climate change on vineyards	Natalie Sellers, *wine-searcher.com*
30 Oct 2020	A.L. Robinson	Researcher in focus profile	Jacquie van Santen, *Wine Australia RD&A news*
10 Nov 2020	E.N. Wilkes	Bottle variation in packaged wine	Sonya Logan, *Wine & Viticulture Journal*
11 Nov 2020	M.L. Longbottom	FACRC sustainability project	Eddie Summerfield, *Macquarie Media group*
20 Nov 2020			Alexandra Laskie*, The Weekly Times*
30 Nov 2020	M.P. Krstic	Viticulturist of the year award	Jacquie van Santen, *Wine Australia RD&A news*
8 Dec 2020	N. Scrimgeour	Canned wines	Simone Madden-Grey, *Winetitles*
15 Jan 2021	S. Nordestgaard	Sustainable winery design	Mark O'Callaghan, *Wine & Viticulture Journal*
22 Jan 2021	M.P. Krstic, M.L. Longbottom	Managing vineyards damaged by fires	Stacy Briscoe, *SevenFifty Daily*
2 Feb 2021	T.M Parker	Early-season smoke exposure	Jacquie van Santen, *Wine Australia RD&A news*
15 Feb 2021	C.A. Simos	Smoke taint	Tony Love, *Wine Business Magazine*
23 Feb 2021	M. Essling	Agrochemical use in viticulture	Gabrielle Duykers, *Naracoorte Community News*
1 Mar 2021	K.A. Bindon	Vintage compression	Jacquie van Santen, *Wine Australia RD&A news*
5 Mar 2021	M.L. Longbottom	Autonomous machinery to replace herbicide	Else Kennedy, *SunraysiaDaily*
15 Mar 2021	I.L. Francis	Salinity in wine research	Alex Russan, *SevenFifty Daily*
17 Mar 2021	C.A. Simos	Smoke taint and controlled burns	Xanthe Gregory, *ABC Central NSW*
30 Mar 2021	M.P. Krstic	Biogenic amines	Jamie Goode, *Wine Enthusiast*
25 May 2021		Bushfires and smoke taint	Cassandra Hough, *ABC Country Hour*
	T.M. Parker	Pre-veraison smoke exposure	
2 Jun 2021	S.A. Schmidt	Aeration of red ferments	Jacquie van Santen, *Wine Australia RD&A news*
10 Jun 2021	M.P. Krstic, M.J. Herderich, E.N. Wilkes	Biogenic amines	Sophie Parker-Thomson, *jancisrobinson.com*
21 Jun 2021	W.P. Pearson	No- and low-alcohol wine production	Sonya Logan, *Aust. N.Z. Grapegrower Winemaker*
23 Jun 2021	J.L. Hixson	Foliar spraying and thiols	Jacquie van Santen, *Wine Australia RD&A news*
29 Jun 2021	M.P. Krstic	Innovation on the Waite Campus	*SA Government Department for Innovation and Skills*

APPENDIX 7

Papers published by AWRI staff recorded during 2021/2021

2180 Dry, P. Arinto de Bucelas. *Wine Vitic. J.* 35(3): p. 59; 2020.

2181 Xing, F., Gao, D., Liu, H., Wang, H., Habili, N., Li, S. Molecular characterization and pathogenicity analysis of prunus necrotic ringspot virus isolates from China rose (*Rosa chinensis* Jacq.). *Arch. Virol.* 165: 2479-2486; 2020.

2182 Varela, C., Bartel, C., Onetto, C., Borneman, A. Targeted gene deletion in *Brettanomyces bruxellensis* with an expression-free CRISPR-Cas9 system. *Appl. Microbiol. Biotechnol.* 104: 7105-7115; 2020.

2183 Teng, B., Petrie, P.R., Espinase Nandorfy, D., Smith, P., Bindon, K. Pre-fermentation water addition to high-sugar Shiraz must: effects on wine composition and sensory properties. *Foods* 9(9): 1193; 2020.

2184 Varela, C., Bartel, C., Espinase Nandorfy, D., Borneman, A., Schmidt, S., Curtin, C. Identification of flocculant wine yeast strains with improved filtration-related phenotypes through application of high-throughput sedimentation rate assays. *Sci. Rep.* 10: 2738; 2020.

2185 Varela, C., Sundstrom, J., Cuijvers, K., Jiranek, V., Borneman, A. Discovering the indigenous microbial communities associated with the natural fermentation of sap from the cider gum *Eucalyptus gunnii*. *Sci. Rep.* 10: 14716; 2020.

2186 Nordestgaard, S. Autonomous vineyard robots and tractors. *Aust. N.Z. Grapegrower Winemaker* (680): 50-52, 54-60, 62, 64, 66-67; 2020.

2187 Essling, M. Ask the AWRI: The importance of soil organic matter. *Aust. N.Z. Grapegrower Winemaker* (680): 82-83; 2020.

2188 Smart, R., Bruer, D., Collins, C., Karantonis, C., Lockshin, L., Muhlack, R., Oemcke, D., Pike, B., Wilkes, E. Towards Australian grape and wine industry carbon neutrality… the possible dream. *Aust. N.Z. Grapegrower Winemaker* (680): 100, 102-105; 2020.

2189 Kang, W., Bindon, K.A., Wang, X., Muhlack, R.A., Smith, P.A., Niimi, J., Bastian, S.E.P. Chemical and sensory impacts of Accentuated Cut Edges (ACE) grape must polyphenol extraction technique on Shiraz wines. *Foods* 9(8): 1027; 2020.

2190 Onetto, C.A., Schmidt, S.A., Roach, M.J., Borneman, A.R. Comparative genome analysis proposes three new *Aureobasidium* species isolated from grape juice. *FEMS Yeast Res.* 20(6): foaa052; 2020.

2191 Pearson, W., Schmidtke, L.M., Francis, I.L., Carr, B.T., Blackman, J.W. Characterising inter- and intra-regional variation in sensory profiles of Australian Shiraz wines from six regions. *Aust. J. Grape Wine Res.* 26(4): 372-384; 2020.

2192 Coulter, A., Cowey, G., Essling, M., Hoare, T., Holdstock, M., Longbottom, M., Simos, C., Krstic, M. Vintage 2020 – observations from the AWRI helpdesk. *Wine Vitic. J.* 35(4): 39-41; 2020.

2193 Cowey, G. Ask the AWRI: Indole off-flavour in sparkling wine. *Aust. N.Z. Grapegrower Winemaker* (681): 46-47; 2020.

2194 Bekker, M.Z., Nandorfy, D.E., Kulcsar, A.C., Faucon, A., Bindon, K., Smith, P.A. Comparison of remediation strategies for decreasing 'reductive' characters in Shiraz wines. *Aust. J. Grape Wine Res.* 27(1): 52-65; 2021.

2195 Cordingley, B. Ask the AWRI: Sparkling wine gushing: not a cause for celebration. *Aust. N.Z. Grapegrower Winemaker* (682): 42-43; 2020.

2196 Haddad, P.R., Taraji, M., Szücs, R. Prediction of analyte retention time in liquid chromatography. *Analyt. Chem.* 93(1): 228-256; 2020.

2197 Essling, M., McKay, S., Petrie, P.R. Fungicide programs used to manage powdery mildew *(Erysiphe necator)* in Australian vineyards. *Crop Prot.* 139: 105369; 2021.

2198 Romanini, E., McRae, J.M., Bilogrevic, E., Colangelo, D., Gabrielli, M., Lambri, M. Use of grape seeds to reduce haze formation in white wines. *Food Chem.* 341: 128250; 2021.

2199 Tondini, F., Onetto, C.A., Jiranek, V. Early adaptation strategies of *Saccharomyces cerevisiae* and *Torulaspora delbrueckii* to co-inoculation in high sugar grape must-like media. *Food Microbiol.* 90: 103463; 2020.

2200 Nordestgaard, S. Sparking a vineyard revolution: Powering up the potential of electric tractors. *Aust. N.Z. Grapegrower Winemaker* (683): 32-34, 36, 38-40, 42-45; 2020.

2201 Godden P. Ask the AWRI: Lees contact in white wine. *Aust. N.Z. Grapegrower Winemaker* (683): 55-56; 2020.

2202 Krstic, M. 2020 Report. *Aust. N.Z. Grapegrower Winemaker* (683): 76-79; 2020.

2203 Dry, P. Lambrusco Maestri. *Wine Vitic. J.* 35(4): p. 60; 2020.

2204 Sui, Y., McRae, J.M, Wollan, D., Muhlack, R.A., Godden, P., Wilkinson, K.L. Use of ultrafiltration and proteolytic enzymes as alternative approaches for protein stabilisation of white wine. *Aust. J. Grape Wine Res.* 27(2): 234-245; 2021.

2205 Siebert, T.E., Stamatopoulos, P., Francis, I.L., Darriet, P. Sensory-directed characterisation of distinctive aromas of Sauternes and Viognier wines through semi-preparative liquid chromatography and gas chromatography approaches. *J. Chromatogr. A* 1637: 461803; 2021.

2206 Schulkin, A., Smith, P.A., Espinase Nandorfy, D., Gawel, R. A little dissolved CO_2 goes a long way in the wine glass. *Wine Vitic. J.* 36(1): 39-41; 2021.

2207 Bekker, M., Espinase Nandorfy, D., Kulcsar, A., Faucon, A., Smith, P., Krstic, M. Choosing the best remediation strategy to remove 'reductive' aromas. *Wine Vitic. J.* 36(1): 42-45; 2021.

2208 McKay, S., Ismail, I., Harper, L., Lopez, F., Van Den Heuvel, S., Borneman, A., Hall, B., Sosnowski, M. Fungicide resistance status of powdery and downy mildew in Australia. *Wine Vitic. J.* 36(1): 54-58, 60-61; 2021.

2209 Dry, P. Moscato Giallo. *Wine Vitic. J.* 36(1): p. 68; 2021.

2210 Coulter, A. Ask the AWRI: Microwaving wine – a scientific perspective. *Aust. N.Z. Grapegrower Winemaker* (684): 44-45; 2021.

2211 Wilkes, E. Smoke analysis at the AWRI: a testing year. *Aust. N.Z. Grapegrower Winemaker* (684): 58-61; 2021.

2212 Dixon, R. Ask the AWRI: Applying regenerative agriculture practices in viticulture. *Aust. N.Z. Grapegrower Winemaker* (685): 40-41; 2021.

2213 Gnoinski, G.B., Schmidt, S.A., Close, D.C., Goemann, K., Pinfold, T.L., Kerslake, F.L. Novel methods to manipulate autolysis in sparkling wine: effects of yeast. *Molecules* 26 (2): 387; 2021.

2214 Essling, M. Ask the AWRI: Use of elicitors in viticulture. *Aust. N.Z. Grapegrower Winemaker* (686): p. 35; 2021.

2215 Varela, C., Bartel, C., Espinase Nandorfy, D., Bilogrevic, E., Tran, T., Heinrich, A., Balzan, T., Bindon, K., Borneman, A. Volatile aroma composition and sensory profile of Shiraz and Cabernet Sauvignon wine produced with novel *Metschnikowia pulcherrima* yeast starter cultures. *Aust. J. Grape Wine Res.* doi:10.1111/ajgw.12484: 1-13; 2021.

2216 Mierczynska-Vasilev, A., Bindon, K., Gawel, R., Smith, P., Vasilev, K., Butt, H-J., Koynov, K. Fluorescence correlation spectroscopy to unravel the interactions between macromolecules in wine. *Food Chem.* 352: 129343; 2021.

2217 Scrimgeour, N., Hirlam, K., Wilkes, E., Parker, M. A burning need: developing a rapid screening method for smoke-affected grapes and wine. *Wine Vitic. J.* 36(2): 33-35; 2021.

2218 Roach, M., Borneman, A., Schmidt, S., Krstic, M. Applying genomics to grapevine clones. *Wine Vitic. J.* 36(2): 39-41; 2021.

2219 Dry, P. Blaufränkisch. *Wine Vitic. J.* 36(2): p. 59; 2021.

2220 Day, M.P., Espinase Nandorfy, D., Bekker, M.Z., Bindon, K.A., Solomon, M., Smith, P.A., Schmidt, S.A. Aeration of *Vitis vinifera* Shiraz fermentation and its effect on wine chemical composition and sensory attributes. *Aust. J. Grape Wine Res*. 27(3): 360-377; 2021.

2221 Zhou-Tsang, A., Wu, Y., Henderson, S.W., Walker, A.R., Borneman, A.R., Walker, R.R., Gilliham, M. Grapevine salt tolerance. *Aust. J. Grape Wine Res*. 27(2): 149-168; 2021.

2222 Cowey, G., Coulter, A. Ask the AWRI: How much sulfur dioxide (SO_2) is needed at bottling? *Aust. N.Z. Grapegrower Winemaker* (687): 76-77; 2021.

2223 Capone, D.L., Barker, A., Pearson, W., Francis, I.L. Influence of inclusion of grapevine leaves, rachis and peduncles during fermentation on the flavour and volatile composition of *Vitis vinifera* cv. Shiraz wine. *Aust. J. Grape Wine Res*. 27(3): 348-359; 2021.

2224 Teng, B., Hayasaka, Y., Smith, P.A., Bindon, K.A. Precipitation of tannin-anthocyanin derivatives in wine is influenced by acetaldehyde concentration and tannin molecular mass with implications for the development of nonbleachable pigments. *J. Agric. Food Chem.* 69(16): 4804-4815; 2021.

2225 Modesti, M., Szeto, C., Ristic, R., Jiang, W., Culbert, J., Bindon, K., Catelli, C., Mencarelli, F., Tonutti, P., Wilkinson, K. Potential mitigation of smoke taint in wines by post-harvest ozone treatment of grapes. *Molecules* 26(6): 1798; 2021.

2226 Pitcher, L. Ask the AWRI: Organic and sustainable production. *Aust. N.Z. Grapegrower Winemaker* (688): 94-95; 2021.

2227 Jiang, W., Parker, M., Hayasaka, Y., Simos, C., Herderich, M. Compositional changes in grapes and leaves as a consequence of smoke exposure of vineyards from multiple bushfires across a ripening season. *Molecules* 26(11): 3187; 2021.

2228 Pearson, W., Schmidtke, L.M., Francis, I.L., Li, S., Hall, A., Blackman, J.W. Regionality in Australian Shiraz: compositional and climate measures that relate to key sensory attributes. *Aust. J. Grape Wine Res.* 27(4): 458-471; 2021.

2229 Schulkin, A., Smith, P.A., Espinase Nandorfy, D., Gawel, R. A little dissolved CO_2 goes a long way in a wine glass. *WBM US* 28(5): 16, 19-20, 22, 24; 2021.

2230 Cordingley, B. Ask the AWRI: *Torulaspora delbrueckii* – An ancient yeast creating new wines. *Aust. N.Z. Grapegrower Winemaker* (689): 64-65; 2021.

2231 Xing, F., Gao, D.H., Wang, H.Q., Zhang, Z.X., Habili, N., Li, S.F. Molecular characterization of rose spring dwarf-associated virus isolated from China rose (*Rosa chinensis* Jacq.) in China. *Arch. Virol.* 166(7): 2059-2062; 2021.

2232 Pearson, W., Schmidtke, L., Francis, L., Li, S., Blackman, J., Carr, T., Krstic, M. Shiraz terroir – linking regional sensory characters to chemical and climate profiles. *Wine Vitic. J.* 36(3): 36-39; 2021.

2233 Dry, P. Trincadeira. *Wine Vitic. J.* 36(3): p. 67; 2021.

2234 Varela, C., Cuijvers, K., Van Den Heuvel, S., Rullo, M., Solomon, M., Borneman, A., Schmidt, S. Effect of aeration on yeast community structure and volatile composition in uninoculated Chardonnay wines. *Fermentation* 7(2): 97; 2021.

2235 Zhang, X.Y., Kontoudakis, N., Wilkes, E., Scrimgeour, N., Hirlam, K., Clark, A.C. The removal of Cu from wine by copolymer PVI/PVP: Impact on Cu fractions and binding agents. *Food Chem.* 357: 129764; 2021.

2236 Taraji, M., Haddad, P.R. Method optimisation in hydrophilic-interaction liquid chromatography by design of experiments combined with quantitative structure-retention relationships. *Aust. J. Chem.* doi: 10.1071/CH21102; 2021.

2237 Modesti, M., Szeto, C., Ristic, R., Jiang, W., Culbert, J., Catelli, C., Mencarelli, F., Tonutti, P., Wilkinson, K. Amelioration of smoke taint in Cabernet Sauvignon wine via post-harvest ozonation of grapes. *Beverages* 7(3): 44; 2021.

2238 Wu, Q., Kehoe, M.A., Kinoti, W.M., Wang, C.P., Rinaldo, A., Tyerman, S., Habili, N., Constable, F.E. First report of grapevine rupestris vein feathering virus in grapevine in Australia. *Plant Dis.* 105(2): 515; 2021.

2239 Godden, P. Ask the AWRI: Effects of fermentation temperature on red wine composition. *Aust. N.Z. Grapegrower Winemaker* (690): 50, 52; 2021.

2240 Bartel, C., Roach, M., Onetto, C., Curtin, C., Varela, C., Borneman, A. Adaptive evolution of sulfite tolerance in *Brettanomyces bruxellensis*. *FEMS Yeast Res.* 21(5): foab036; 2021.

2241 Nicolotti, L., Hack, J., Herderich, M., Lloyd, N. MStractor: R work-flow package for enhancing metabolomics data pre-processing and visualization. *Metabolites* 11(8): 492; 2021.

2242 Varela, C., Cuijvers, K., Borneman, A. Temporal comparison of microbial community structure in an Australian winery. *Fermentation* 7(3): 134; 2021.

2243 Dixon, R. Getting the most out of your water. The importance of irrigation system efficiency. *Aust. N.Z. Grapegrower Winemaker* (691): 40-42, 44-45; 2021.

2244 Coulter, A. Ask the AWRI: Titratable acidity increase during fermentation. *Aust. N.Z. Grapegrower Winemaker* (691): 68, 70; 2021.

2245 Cordente, A.G., Espinase Nandorfy, D., Solomon, M., Schulkin, A., Kolouchova, R., Francis, I.L., Schmidt, S.A. Aromatic higher alcohols in wine: implication on aroma and palate attributes during Chardonnay aging. *Molecules* 26: 4979; 2021.

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2247 Culbert, J.A., Jiang, W., Bilogrevic, E., Likos, D., Francis, I.L., Krstic, M.P., Herderich, M.J. Compositional changes in smoke-affected grape juice as a consequence of activated carbon treatment and the impact on phenolic compounds and smoke flavor in wine. *J. Agric. Food Chem.* 69(35): 10246-10259; 2021.

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2249 Carrau, F., Henschke, P.A. *Hanseniaspora vineae* and the concept of friendly yeasts to increase autochthonous wine flavor diversity. *Front. Microbiol.* 12: 702093; 2021.

2250 Onetto, C.A., Borneman, A.R., Schmidt, S.A. Strain-specific responses by *Saccharomyces cerevisiae* to competition by non-*Saccharomyces* yeasts. *Fermentation* 7(3): 165; 2021.

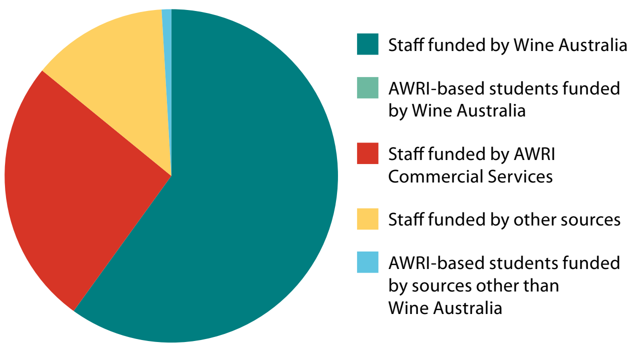

Figure 23. Funding of AWRI staff and students, excluding visiting researchers and visiting students

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