ARC TRAINING CENTRE FOR INNOVATIVE WINE PRODUCTION

ARC Training Centre for Innovative Wine Production

Activity update - 2018/19

DIRECTOR'S WELCOME AND REPORT

Welcome to this report from the ARC Training Centre for Innovative Wine Production. I take great pride in the fact that not only has our team helped ensure that the initial ARC Training Centre for Innovative Wine Production (TC1) was one of the top-ranked bids in 2012 in the then new scheme, but that we were the first Training Centre to succeed in securing a second term (TC2).

This report provides an update of our recent activities, through a period that includes the transition from TC1 to TC2. At the time of writing, all of the PhDs in TC1 had submitted their thesis – a great result and credit to them, their perseverance and the supervisory team of academic and industry partners who supported them. Our attention now turns to the establishment and execution of a suite of some 20 new projects. Projects that aim to address new and old challenges that plague the wine industry.

To date, we have recruited about two thirds of our early career researchers (ECRs). Collectively they have: completed a comprehensive comparison of Cabernet Sauvignon wines from multiple regions, surveyed several grape varieties for their unique microflora, and established methods and trials to explore grapevine bud fruitfulness, berry heterogeneity, the grape berry vascular system, potassium in berry development and the sugar flavour nexus. Other projects examine the rapid assessment of grapes, smoke taint amelioration, extraction and evolution of colour and polyphenols in red winemaking as well as filtration methods for efficient wine processing.

We have already expanded the funding and participant base to our Centre. Meanwhile, our industry and researcher partners have engaged heavily with our students and postdocs, with some of these ECRs taking advantage of extended placements with partners, including those located overseas, to progress their projects and enhance their understanding of industry needs. I invite you to peruse our report, learn about our participants, their plans and achievements.

Professor Vladimir Jiranek
Director

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OUR MISSION AND AIMS

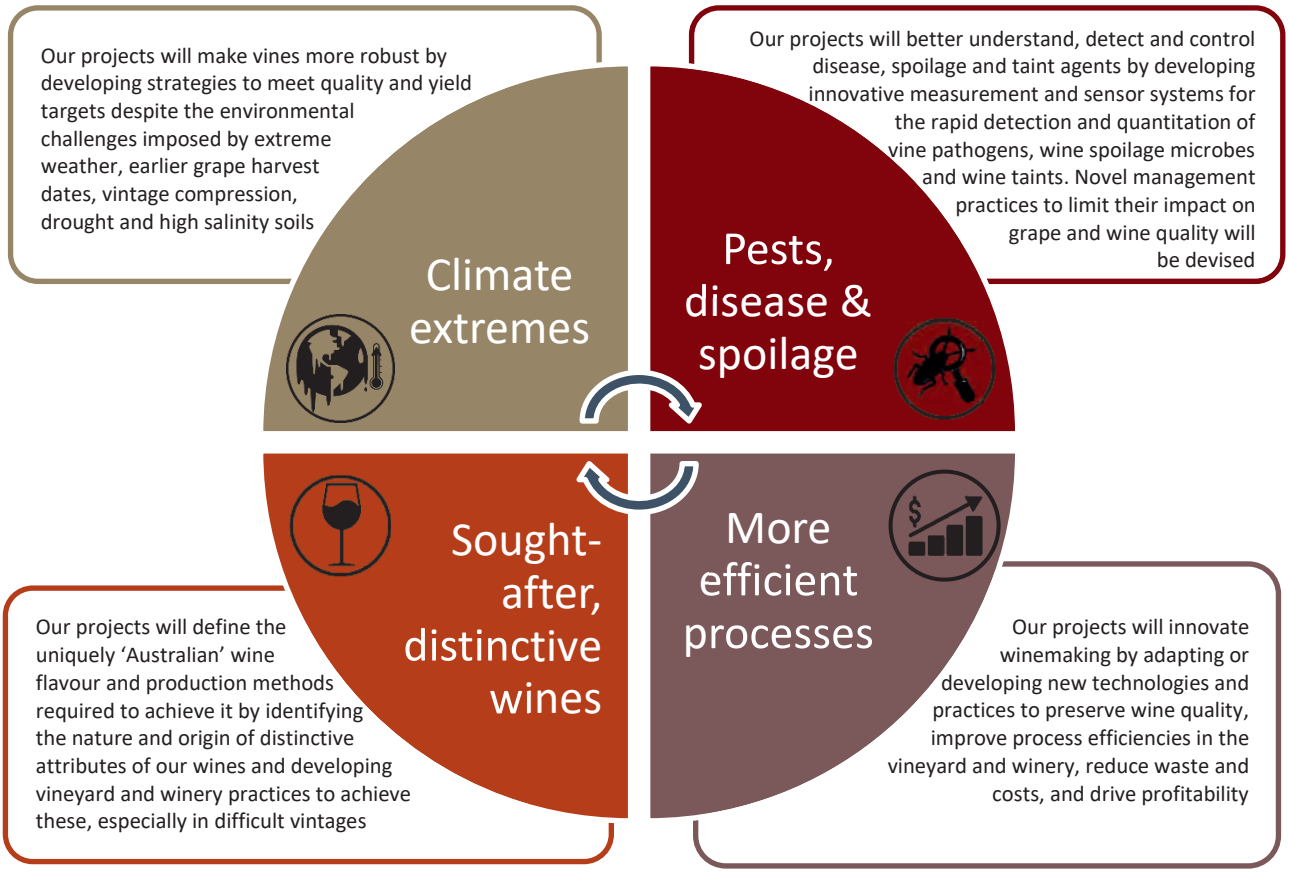
The ARC Training Centre for Innovative Wine Production will tackle new and age-old challenges to wine production, through innovative, multi-disciplinary research over five years. Focusing on responding to challenges and increasing profitability, the Centre's research projects fall into four broad themes: i) climate extremes, ii) pest, disease and spoilage, iii) sought after distinctive wines, and iv) more efficient processes. There are a number of projects that will tackle viticultural issues where a number of challenges lie including; planting the right material, ensuring vine field survival and performance, and ensuring wine quality. Other projects will provide novel tools to tailor wine composition and increase efficiency in the winery.

Outcomes from research within the Centre will build Australia's competitive edge, by sustainably boosting the wine industry's profitability and resilience to challenges, while providing excellent research training and greater innovation capacity.

The specific aims of the Centre are to:

- Make grapevines more robust
- Better understand, detect and control disease, spoilage and taint agents
- Define the uniquely 'Australian' flavour proposition and methods to attain it
- Innovate winemaking by adapting and/or developing new technologies and practices
- Provide research training excellence for higher degree by research students and postdoctoral researchers
- Pursue commercialisation and/or adoption of project outputs

The Centre's multi-disciplinary team of researchers and industry partners have experience that spans the grape growing and wine processing value chain. Our research projects will be undertaken in conjunction with our industry partners, providing our student and post-doctoral researchers with valuable research training with a focus on end-user commercialisation.



ARC Training Centre for Innovative Wine Production

Training Centre Director
Vladimir Jiranek

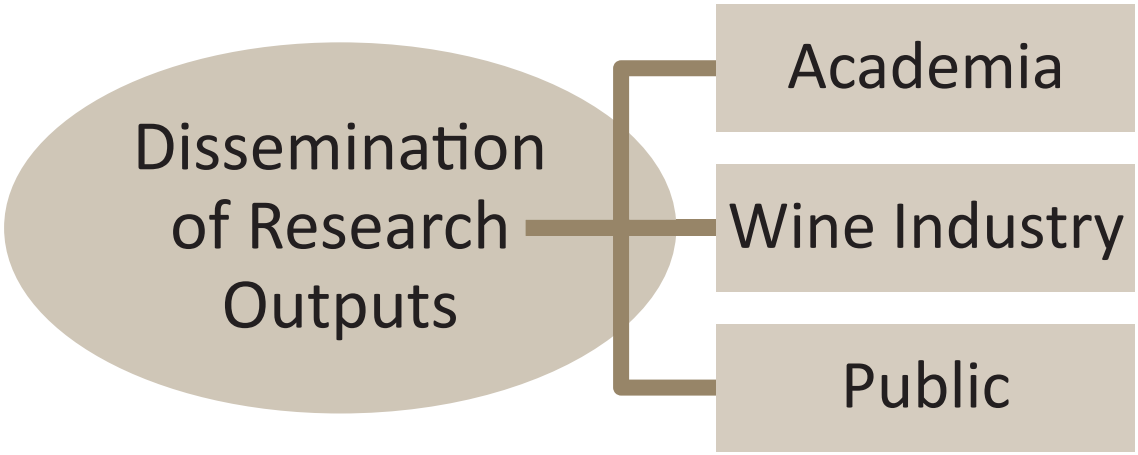
- Researchers: 16 HDRs; 4 PDFs
- Chief Investigators
- Partner Investigators
- Associate Investigators
- Technical and Support Staff
- Research Staff (Funded by Wine Australia)

Advisory Board

Dr Eveline Bartowsky (Lallemand)
A/Prof Paul Boss (CSIRO)
Christopher Brodie (Coonawarra Grape & Wine Inc)
Kim Chalmers (Chalmers Wines)
Dr Nick Dokoozlian (E&J Gallo)
Andrew Grant (Availer)
Prof Markus Herderich (AWRI)
Dr Jean Macintyre (Pernod Ricard Winemakers)
A/Prof Suzy Rogiers (NSW DPI)
Prof Leigh Schmidtke (CSU)
Dr Gethin Thomas (AGRF)
Dr Liz Waters (Wine Australia)
David Wollan (VA Filtration)

Observers

Joanna Sundstrom - Centre Manager
Renata Ristic - Research Coordinator
Anne Auricht - Administrative Officer



OUR PEOPLE

Training Centre Director

Prof Vladimir Jiranek
Univeristy of Adelaide

Chief Investigators

A/Prof David Jeffery
University of Adelaide

Prof Steve Tyerman
University of Adelaide

Prof Kerry Wilkinson
University of Adelaide

A/Prof Susan Bastian
University of Adelaide

Dr Richard Muhlack
University of Adelaide

A/Prof Cassandra Collins
University of Adelaide

Dr Vinay Pagay
University of Adelaide

Prof Matthew Gilliham
University of Adelaide

A/Prof Christopher Ford
University of Adelaide

A/Prof Paul Grbin
University of Adelaide

Prof Leigh Schmidtke
Charles Sturt University, NWGIC

Partner Investigators

A/Prof Suzy Rogiers
NSW DPI

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AGRF

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Chalmers Wines

Prof Markus Herderich
Australian Wine Research Institute

Dr Anthony Borneman
Australian Wine Research Institute

Dr Nick Dokoozlian
E & J Gallo

Other Investigators

Dr Liz Waters
Wine Australia

Dr Eveline Bartowsky
Lallemand

Andrew Grant
Availer

Associated Investigators

Dr Jacqui McRae
University of Adelaide

Prof Dabing Zhang
University of Adelaide

Dr Alexander Donald
University of NSW

Research Staff

Dr Renata Ristic
Research coordinator
University of Adelaide

Professional Staff

Dr Joanna Sundstrom
Training Centre Manager
University of Adelaide

Nick van Holst Pellekaan
Facilities Manager
University of Adelaide

Anne Auricht
Administration Officer
University of Adelaide

The ARC Training Centre for Innovative Wine Production brings together an exceptional team of researchers and collaborators.

OUR PROJECTS

TC-IWP research focuses on issues relevant to the wine industry

Across the value chain from vineyard to winery

VASCULAR TRANSPORT INTO THE BERRY IMPACTS ON FRUIT SIZE AND COMPOSITION

Project leader: Dr Suzy Rogiers
Researcher: Dr Zeyu Xiao
Commenced: March 2018
Industry partner: NSW DPI

"My goal for the project is to develop a deeper understanding of the grape berry vascular system and its functions. The knowledge on the underlying mechanisms driving vascular flow into grape berries will better inform the Australian wine grape growing industry on fertigation and other management factors that can be implemented to optimise berry composition and yield."

Fruits, roots and leaves are interconnected by a dynamic vascular system allowing mass transport of essential materials and a means for whole plant communication and integration. Long distance transport via the grapevine's xylem/phloem network ultimately defines fruit size and composition, impacting yield and wine style. This project will define the mechanisms driving xylem/phloem flow and demonstrate how their close connection dictates water, carbohydrate, ion and signal flow to the berry. Knowledge of the physiological factors driving grape development will help define management strategies to fine tune berry composition.

Study 1 in vascular anatomy examines vascular patterns within the proximal region of Shiraz, Sauvignon Blanc, Ruby Seedless and Flame Seedless berries. This region is a critical branching point for vascular tissues that supply either the peripheral network under the skin or the central bundles that lead to the seeds and berry interior (Figure 1).

The second study uses Magnetic Resonance Imaging (MRI) to visualise grapevine vascular structures of the major organs and quantify directions of flow and flow rates through the vascular tissues of the grapevine, with emphasis on the bunch, prior to and after the onset of ripening. Knowledge on the underlying mechanisms driving vascular flow into grape berries will better inform the grape and wine industries on fertigation and other management factors that can be implemented to optimise grape composition and yield.

The third study investigates the feasibility of using rootstocks to lower berry potassium (K^+) concentrations in Cabernet Sauvignon grapevines grown in the Coonawarra wine region. The objective is to provide new insights into the potential of particular rootstocks to modify K^+ uptake by Cabernet Sauvignon grapevines grown in 'Terra Rossa' soil and their partitioning and accumulation into grape berries.

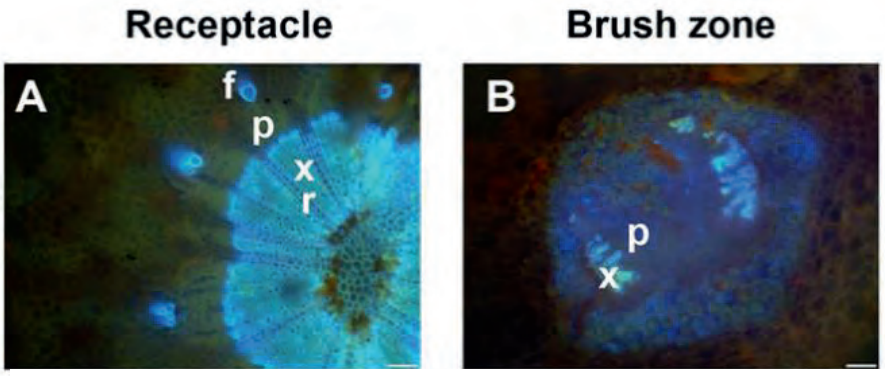
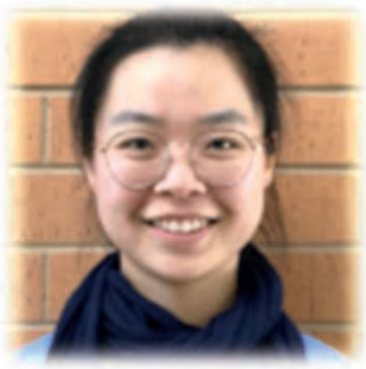


Figure 1. Vascular arrangement in the receptacle (pedicel) and the berry brush zone (central) (x, xylem; p, phloem; r, xylem ray; f, phloem fibre). Scale bar = 100 µm.

INVESTIGATING THE ROLES OF POTASSIUM IN BERRY RIPENING AND CELL DEATH

Project leader: Dr Suzy Rogiers
Researcher: Yin Liu
Commenced: July 2019
Industry partner: NSW DPI



"I am aiming at a contribution to science and useful suggestions to industry."

Several ions play important developmental roles in the grape vine. Potassium (K^+) is reported to positively correlate with the pH of juice and simultaneously accumulates with sugar into the berry through the vascular system. Limiting K^+ accumulation in berry could potentially reduce juice sugar content and modify acidity. However, K^+ plays important roles in maintaining cell vitality and increases resistance against stress and disease.

This project will investigate the transport of K^+ into and within the berry, and explore potential links between K^+ and berry cell death which may be involved in berry shrivel. This will allow us to better understand the roles of K^+ in berry development and ripening, and to find potential methods to manipulate berry composition.

BREAKING THE SUGAR FLAVOUR NEXUS GROWING GRAPES WITH MORE FLAVOUR AND LESS SUGAR

Project leader: A/Prof Christopher Ford
Researcher: Pietro Previtali
Commenced: April 2018
Industry partner: E&J Gallo Winery

As grapes ripen sugar accumulates by translocation into the bunches, while at the same time a range of specialised flavour compounds are produced by metabolic activities within the berries.

These processes display a seemingly tightly linked pairing at the level of individual berries, which is lost at the bunch level due to its heterogeneity. During the 2019 vintage berries were analysed within 5 developmental stages and a general correlation between the chemical composition of individual berries and the stage of development was observed, particularly for most of the C_6 compounds responsible for green and leafy notes in wines. Further understanding of the metabolism behind the apparent linkage of these events will help growers develop practices to maximise flavour production without excessive sugar, and hence alcohol, in wines.

"I am looking forward to getting the most out of this new learning journey that is not exclusively limited to grapes and wine, but it is made of people, sciences and places. I hope I will be able to shed some light on the processes involved in flavour accumulation, one of the most intriguing sides of grape ripening."

MOLECULAR CONTROL OF GRAPEVINE BUD FRUITFULNESS

Project leader: Prof Matthew Gilliham
Researcher: Xiaoyi (Eva) Wang
Commenced: December 2018
Industry partner: CSIRO

The majority of main wine producing grapevine varieties grown today have been produced through clonal propagation. This has narrowed grapevine genetic diversity and leaves them susceptible to climate change and disease pressures.

This project will explore the genetic factors that underpin natural variation in reproductive development and yield, specifically inflorescence primordia development and how this relates to bunch number and bunch architecture in established and alternative varieties. Understanding the genetic control of the developmental process will be helpful in grapevine breeding and for the management of vineyards to regulate yield and ensure consistent production under the global warming situation.

"My project focuses on the molecular control of grapevine reproductive performance and will bring novel insights into the regulatory mechanism for inflorescence primordia initiation and differentiation. It's such an exciting and challenging study and I look forward to filling in some small pieces of the puzzle of grapevine genetics."

RAPID ASSESSMENT OF GRAPES PRIOR TO HARVEST TO QUANTIFY FUNGAL OFF-FLAVOURS AND PRODUCT COMPOSITION

Project leader: Prof Leigh Schmidtke
Researcher: Dr Morphy Dumlao
Commenced: March 2019
Industry partner: NSW DPI

"This new innovation will hopefully aid growers and winemakers in ensuring quality and objective assessment, thereby offering better wine to consumers, but could also be applied more broadly to other horticultural crops."

Grape producers are often pressured by the logistics of harvest, transport and wine production, and the need to coordinate with the ripening of other grape varieties. Vintage compression, late rains and the associated mould growth and off-flavours magnify the problem. Rapid objective methods to assess grape quality and mould taints would substantially aid decision-making and grading of grapes in a timely manner. Current grape assessment techniques are time consuming and require a high level of technical skill for reliable results.

This project will develop in-field assessment of grape quality, composition and fungal taint compounds. The work builds upon our expertise for quantifying volatiles linked to grape fungal infection and will extend to volatiles linked to wine faults and taints. Currently, the focus is on development of a rapid and direct method for the detection of volatile grape biomarkers using mass spectrometry. Firstly, a library of different adsorbent materials with ultrahigh surface areas that selectively capture our target compounds will be synthesised and characterised. Secondly, a new sampling and ionisation source for mass spectrometry will be developed that enables analytes to be selectively and rapidly detected by integrating thermal desorption with ambient ionisation for the first time (Figure 2). The performance of this library of thermal desorption materials and this ionisation approach will be compared to that of commercially available materials (*e.g.* polymer Tenax) and instrumentation (*i.e.* gas chromatography mass spectrometry).

This near real-time methodology for detecting volatile organic compounds is promising. It takes less than 2 mins per sample which is significantly shorter than previously reported techniques for the analysis of the phytosanitary aspects of grapes. A full method validation, quantitative studies, and an optimisation for the detection of real samples are currently in progress.

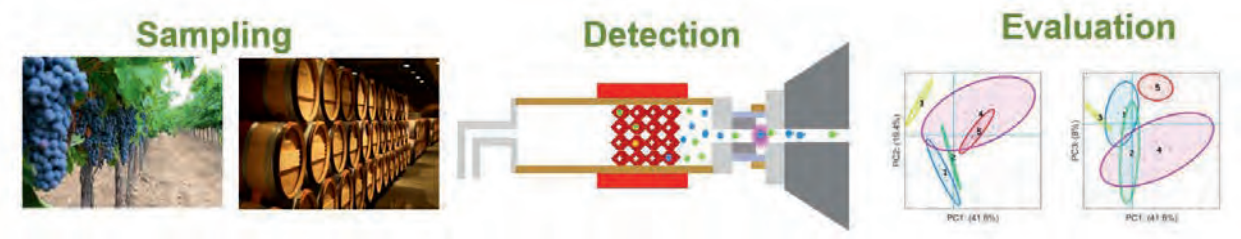


Figure 2. Schematic diagram of a rapid in-field assessment of off-flavours and product composition

OVERCOMING TAINT FROM VINEYARD EXPOSURE TO BUSHFIRE SMOKE

Project leader: Prof Kerry Wilkinson
Researcher: Colleen Szeto
Commenced: May 2018
Industry partner: E&J Gallo Winery

Bushfire frequency and severity have increased due to climate change. Taint from vineyard exposure to smoke remains an issue of major concern for grape and wine producers worldwide, and an ongoing threat to long-term economic viability, despite significant scientific progress over the past decade. Research in this issue has been focused on the detection and amelioration of smoke taint in grapes and wine, but limited work has been directed towards preventative strategies that monitor or limit vineyard exposure to smoke.

Field trials were undertaken in 2019 to investigate the impact of smoke density levels on the intensity of smoke taint in grapes and wine and examine the efficacy of a novel vineyard mitigation strategy: continuously spraying mist in the grapevine canopy throughout experimentally administered smoke exposure. While misting does not appear to prevent the uptake of smoke by grapes, the results depict a complex story regarding the accumulation of key chemical marker compounds in grapes as a result of smoke exposure. These findings have warranted further research into the biochemical pathways underlying accumulation and new methods of smoke taint risk analysis.

"A PhD inherently grants the acquisition of very deep and specific pieces of knowledge, but more than anything, I think it is akin to an endurance exercise regime for the brain. Even within the first few months, I have been immersed in project management, collaboration dynamics, networking, and critical analysis. Throughout this journey, I look forward to enhancing my fluidity in this new environment and continuing to shape my professional side."

MANAGING BERRY HETEROGENEITY

Project leader: A/Prof David Jeffery
Researcher: Claire Armstrong
Commenced: October 2018
Industry partner: CSIRO

Uneven ripening and variability in berry composition and size across the vineyard can be detrimental to wine style consistency and quality. Growers of premium grapes seek to minimise such heterogeneity by selectively thinning slow developing berries or by sorting post harvest, which are both costly and time consuming methods. Ideally, uniformity would be achieved by vineyard manipulations during ripening, as well as yield grapes with lower sugar (thus lower wine alcohol) content, and reduce losses due to 'dropping' or sorting fruit. Initial investigations were made on intra-cluster variation of grape total soluble solids, colour and size throughout development and at harvest using chemical data and image analysis.

A small-lot wine making method was followed to investigate the impact that grape heterogeneity has on wine quality by blending proportions of grapes which varied in total soluble solid content and then analysing the final wines chemical composition and sensory attributes. Furthermore, preliminary findings on the effect of LalVigne® MATURE foliar spray on grape maturity variation at the time of harvest were made.

In the upcoming vintages, we aim to examine the interaction between crop load and irrigation and their effects on grape heterogeneity throughout development and at the time of harvest.

"Overall, I aim to thoroughly improve our understanding of intra-cluster heterogeneity of grape berry maturity so vineyard management techniques can be applied to minimise heterogeneity at harvest and overcome its effects on wine quality. I hope to develop an analytical method to evaluate intra-cluster variability that is non-destructive and applicable to further field studies and possibly adoptable by industry. A personal goal of mine is to gain practical knowledge and skills in the wine industry, as well as advance myself as an independent and collaborative researcher."

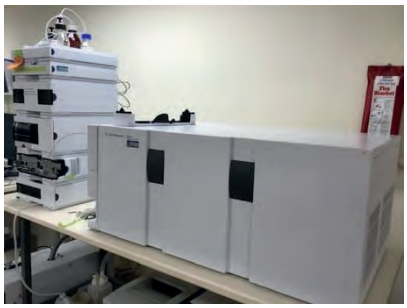
CHARACTERISING THE DISTINCTIVE FLAVOURS OF AUSTRALIAN CABERNET SAUVIGNON WINES

Project leader: A/Professor David Jeffery
Researchers: Dr Dimitra Capone and Lira Souza Gonzaga
Commenced: March 2018 (Dimi) and July 2018 (Lira)
Industry partners: Coonawarra Vignerons, CSIRO

Grapegrowing and winemaking to suit the market will enable Australia's wine sector to be more competitive in a challenging environment. There is demand for wines that express the unique characteristics of their place of origin but in many cases those characters are not well defined. Many grape components strongly influence wine quality and style, including certain varietal wine aroma compounds that can be traced to specific grape metabolites.

This project aims to understand the chemical and sensorial basis of regional typicity of Coonawarra Cabernet Sauvignon, a commercially-important red variety, and to determine how pragmatic and cost-effective vineyard and winemaking practices can be used to alter grape and wine characteristics to meet consumer-preferred wine styles, whether in traditional Western or booming Asian markets. 84 commercial Cabernet Sauvignon wines were profiled for their chemical and sensory properties. Accurate chemical methods have been established and used to determine a range of different analytes arising from grape, fermentation, and oak. Preliminary assessment of the data has shown that the Australian Cabernet Sauvignon wines contained significantly more "green capsicum" aroma compound than those from Bordeaux. In addition, "varietal thiols" (tropical fruit characters) that are rarely measured in red wines appeared to be significantly higher in Yarra Valley and Margaret River wines compared to Bordeaux and Coonawarra. Once complete, the chemical data set will be used together with the sensory results to establish which compounds are most important in describing particular sensory attributes of the regions.

Dimitra Capone: "My personal goal in the TC is to understand the important regional drivers of Cabernet Sauvignon flavour profile. I would like to lead exciting new research initiatives that derive from my work and to help foster the next generation of Australian scientists."



Lira Souza Gonzaga: "My goal is to be able to provide the Australian wine industry with insights on how to manipulate and enhance their wine typicity and target it to the right consumers in the right way."

The first array of sensory analyses of regional Cabernet Sauvignon wines was performed by an expert panel. The wines were selected based on a webscraping method of online reviews of well known wine writers. Distinct sensory profiles arose that could be related to region of origin, but it was not possible to perfectly cluster the wines based on region. One profile was characterised by aromas of *dark fruit*, *vanilla*, *chocolate*, and *spice* aromas, a second profile by *floral*, *red fruit*, *confectionery*, and *minty* aromas, and a third profile by *barnyard* and *cooked vegetables* aromas. The last profile was mostly associated with *herbaceous* and *eucalyptus* aromas. The regional and quality profile also had some concordance with the online reviews.

Greater distinction was seen between Bordeaux wines and those from Australia, as opposed to extensive differentiation within Australian regions, although some representative trends were observed.

DEFINING AND EXPLOITING THE INDIGENOUS MICROFLORA OF GRAPES

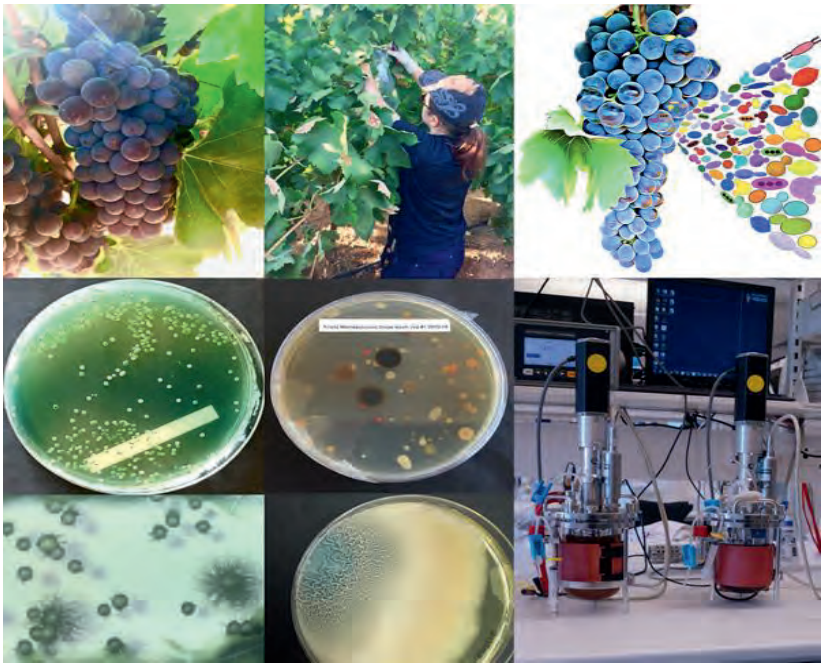
Project leader: Prof Vladimir Jiranek
Researcher: Dr Krista Sumby and HDR
Commenced: February 2018 (Krista) and 2020 (HDR)
Industry partners: AGRF, AWRI, Chalmers Wines, Lallemand

"I look forward to more opportunities to speak to grape growers and wine makers instead of just my yeast cultures. I want to develop a better understanding for what the industry is interested in and participate in strategic development to address the industry's current and future needs."

A diverse community of yeast and bacteria are present on grapes and therefore will transfer into winemaking with the possibility of influencing wine processing and sensory properties. This community can produce many benefits for winemaking including but not limited to the liberation of aroma precursors and positive enzymatic activities. This project is utilising the unique resource of a single block of many grape varieties and clones on the same soil, encountering the same climatic conditions, to determine the impact of grape variety only on microbial terroir. Different varieties and particularly their inherent phenology, skin thicknesses, grape and bunch architecture, attractiveness to animal and insect pests, are expected to favour different microbial populations.

Fresh berries from multiple grape varieties have been collected to identify indigenous yeast and bacterial species present in the vineyards of the industry partner, Chalmers in Merbein, Victoria. By using both culture-based and culture-independent methods we can reveal these microorganisms and study population diversity and profile, with the latter generally uncovering more species, some in very small numbers. With the rise in popularity of indigenous (un-inoculated) fermentations the wine microbial community as a whole is becoming more important and deserves to be studied in greater detail.

During the first vintage (2018) a number of isolation methods were used to culture yeast and bacteria yielding over 3,000 single colonies. During the second vintage (2019) the overall fungal fingerprint was determined for 12 grape varieties (including 2 clones), by sequencing the total population on each bunch (microbiome). This will be continued over the next two vintages to investigate if climate/time are factors causing microbial variation or if the microbiome is stable on each grape variety.



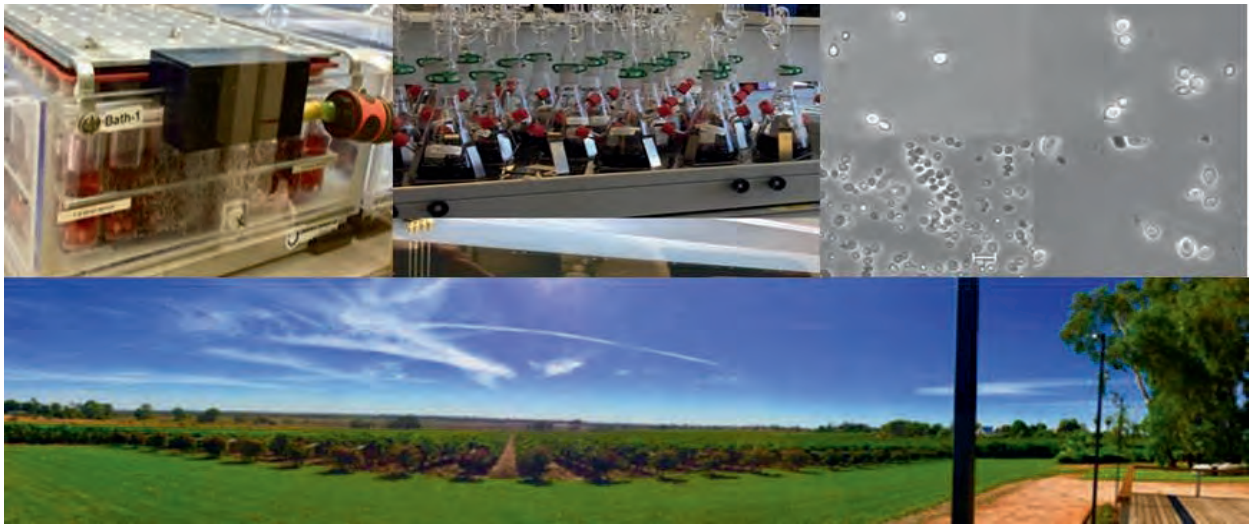
SHAKING UP THE MICROBIOLOGY OF WINEMAKING

Project leader: Prof Vladimir Jiranek
Researcher: Dr Krista Sumby
Commenced: February 2018
Industry partner: Lallemand

Winemakers continue to seek opportunities to achieve diversity in wine sensory properties whilst retaining control and reliability in winemaking. Whilst many winemakers are choosing not to inoculate their juice for alcoholic fermentation (AF), allowing indigenous non-*Saccharomyces* to initiate AF, this can lead to stuck fermentations largely due to their inability to tolerate ethanol. Unlike several hundred *Saccharomyces* yeast strains, only ~6 non-*Saccharomyces* yeast strains are available and none complete fermentation, necessitating inoculation with a *Saccharomyces* wine strain to achieve this. Additionally, many red and white wines are inoculated for Malolactic fermentation (MLF) with lactic acid bacteria (LAB), either as a co-inoculant or following AF. MLF involves the bioconversion of malic acid to lactic acid and carbon dioxide. The ability to metabolise malic acid is strain specific, and both individual *Oenococcus oeni* strains and other LAB strains vary in their ability to efficiently carry out MLF.

MLF is notoriously problematic and can very easily impact wine quality negatively. There is therefore great interest in non-*Saccharomyces* strains and LAB that are more resistant to the stressors found in juice and wine. Inoculation with superior non-*Saccharomyces* yeasts and LAB should provide greater process reliability and predictability of fermentation outcome (at least in terms of absence of undesirable sensory properties) than un-inoculated fermentation. This project seeks to both generate more robust non-*Saccharomyces* (able to ferment alone) and LAB, and to find novel attributes of non-*Saccharomyces* that could benefit winemakers. Promising yeast and LAB strains isolated in the Project 2 "Defining and exploiting the indigenous microflora of grapes" will be subjected to directed evolution (DE) which involves an organism mutating and potentially adapting to a high stress environment over the course of extended cultivation.

This project is using samples from both our industry partners (Lallemand and Chalmers Wine) along with a range of methods to improve them or screen for useful activities. Over 500 isolates of stored samples from Project 12 have already been identified and screened for their ability to conduct alcoholic fermentation in red and white juice. This project plans to generate a number of new microbial strains for industry to increase the winemakers microbial toolkit.



EFFICIENT RED WINEMAKING BY MONITORING EXTRACTION AND EVOLUTION OF COLOUR AND POLYPHENOLS

Project leader: Dr Richard Muhlack
Researcher: Judith Unterkofler
Commenced: November 2018
Industry partner: Pernod Ricard Winemakers

"I am looking forward to this great opportunity of working closely with the Australian Wine Industry and with world class experts of the field. I hope that my work experience in industry will help bridge academia research and industry in this project. My aim is that my research will have a positive impact on wine production efficiency by providing a tool that predicts phenolic extraction and thus wine quality."

Process control and automisation have become more and more important in all production industries as they provide an optimisation of plant efficiency, plus increased and consistent product quality. The quality of red wine is highly dependent on its phenolic compounds that are extracted into the wine during the fermentation. These compounds, among other things, influence the colour, mouthfeel, bitterness and astringency of the wine. Yet there are no automated process controls used in industry to monitor phenolic extraction, which could guarantee a certain quality. This extraction is dependent on grape characteristics, however, these are not only different for each batch, but can also change yearly. Therefore, no set standardised production and monitoring procedure can be put in place.

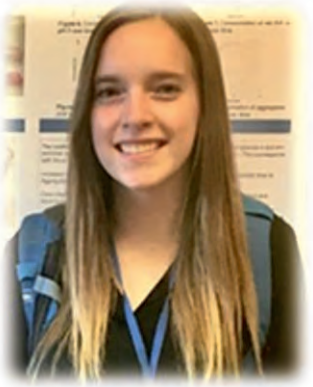
This project intends to further develop dynamic mathematical simulation models for the extraction and reaction of phenolics in red wine ferments. These models will predict the phenolic extraction of the individual grape batches and will then be implemented into a process control system with in-line measurement instruments during the maceration. This will facilitate efficient production and increase wine quality and plant availability. In 2019 fermentation samples from 3 different varieties in five 180 tonne fermenters were collected in a commercial winery and analysed for anthocyanin extraction. At the same time, an extraction model incorporating cap management procedures, fermentation temperatures, and the content of sugars and alcohols, was applied. The model showed promising results in prediction of the anthocyanin concentration for Shiraz and Merlot, however, due to the berry size and skin thickness of Cabernet Sauvignon grapes the model needs further adjustment. Such models together with real-time data acquisition during fermentation will help future development of automatic process control systems for optimised extraction through temperature control and cap management.

MATHEMATICAL MODELLING OF RED WINE COLOUR AND POLYPHENOLS EXTRACTION AND EVOLUTION TO ENHANCE WINEMAKING EFFICIENCY

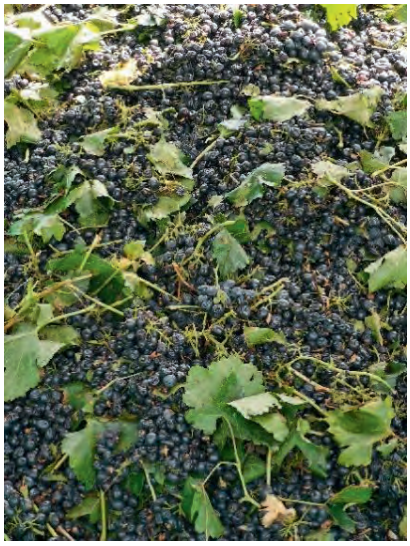
Project leader: Dr Richard Muhlack
Researcher: Rachael Tindal
Commenced: August 2019
Industry partners: Pernod Ricard Winemakers

This project will develop dynamic and spatial mathematical models for the extraction and reaction of phenolic compounds during various stages of the red winemaking process. By providing a kinetic and spatial basis for phenolic behaviour, these models will significantly enhance the existing understanding of phenolic compound extraction and reaction mechanisms which are critical to wine quality. This will allow for the development of predictive tools for phenolic extraction, allowing for increased wine quality with efficient production and reduced costs.

Phenolic extraction and reaction is vital to final red wine quality and colour. Work has been established regarding these mechanisms, although very few models examine phenolic behaviour during post-extractive reactions and wine ageing processes. There is great interest in developing these models, and expanding them to include different anthocyanin species, process variables, and spatial properties. Phenolic post-extraction mechanisms contribute highly to red wine quality and colour, and understanding these processes would lead to the development of optimised final red wine products and efficient winemaking operations.



"I am looking forward to being involved with this research project and spending time with the TC-IWP. I think this project poses some really interesting questions and will result in meaningful applications for winemakers and others in industry. This is an exciting experience and I am thankful to get to be a part of it."



MEMBRANE FILTRATION TECHNOLOGIES FOR EFFICIENT WINE PROCESSING AND RECOVERY OF VALUABLE EXTRACTS

Project leader: Prof Kerry Wilkinson
Researcher: Yihe (Eva) Sui and HDR
Commenced: April 2018 (Eva) and 2020 (HDR)
Industry partners: AWRI, VA Filtration

Protein stability is critical to white and rose wines. Unstable wine may become hazy or cloudy or even form precipitates during transportation, storage or after heat exposure, which consumers generally consider to be a sign of poor quality. Conventionally, bentonite, a type of clay, is used as a fining additive during winemaking to remove unstable proteins. Although widely used by industry, bentonite fining can strip wine aroma and flavour, and introduce metal ions. Moreover, the inability to recover wine 'trapped' in the loosely settled bentonite lees, which can comprise 3–10% of the total wine volume, represents a financial loss to the wine industry every year. Previous research has explored alternatives to bentonite that can be used to remove unstable wine proteins.

This project aims to evaluate membrane filtration as a novel method for removing haze forming proteins, thereby expanding the application of this technology in wine production.

In 2019, wine proteins were fractionated by membrane filtration (MF) using a bentch top filter on two wine samples. After that, heat and/or enzyme treatment, using a purpose-built heat treatment unit, was applied to remove proteins from the resulting retentate fraction in order to stabilise wine after treated retentate was recombined with permeate. The results show that: 1) MF using moleculer weight cut off of 10k Da membrane can achieve heat-stable permeate and 2) heat treatment with specific enzyme addition for 10 minutes can reduce the level of haze forming proteins in retentate.

"With the support of my supervisors and our industry partners, I hope to overcome white wine protein stability issues using cleaner and more efficient membrane technology. I hope my research project will benefit the wine industry and provide a viable option for winemakers to achieve protein stability in wine, with confidence that wine quality will be retained."

OTHER PROJECTS

INTER-VINE SIGNALLING VIA PLANT VOLATILES

Project leader: Dr Vinay Pagay
Researcher: to start in 2020
Industry partners: AGRF, NSW DPI

Plants emit and respond to an array of volatile organic signalling molecules under conditions of biotic and abiotic stresses. Although unknown in grapevines, preliminary evidence from potted grapevines shows that water-stressed vines communicate with their well-watered neighbours and elicit a physiological water stress response. This project will test the hypothesis that during stress or key phenological events (e.g. fruit-set or ripening), 'source' vines emit volatile signals that induce 'receiver' plants to respond in kind. This work will be the first scientific characterisation and demonstration of inter-vine signalling of water stress.

GENETIC BASIS OF SALT EXCLUSION IN GRAPEVINE

Project leader: Prof Matthew Gilliham
Researcher: to start in 2020
Industry partners: AGRF, AWRI, CSIRO

Soil salinity costs the Australian grape and wine industry ~$60M pa in lost yield. Salt accumulation in berries also reduces wine quality, with wine from many Australian regions susceptible to exceeding legal limits for sodium and chloride ions leading to wastage. This project will identify genes from *Vitis* spp. rootstocks, that confer salt exclusion in the grapes of grafted *V. vinifera* scions, to accelerate the selection of rootstocks specifically designed for production in Australian conditions. Genes identified by genotyping-by-sequencing of the progeny of crosses between salt-including and salt-excluding rootstocks, will undergo molecular and physiological characterisation.

ALTERNATIVES TO SO_2 FOR CONTROLLING *BRETTANOMYCES* SPOILAGE IN WINE

Project leader: A/Prof Paul Grbin
Researcher: TBA
Industry partners: AGRF, AWRI, Pernod Ricard

Brettanomyces is a yeast associated with wine spoilage, particularly during storage. Sulfur dioxide (SO_2) is the most commonly approach used to control this yeast. However, the use of SO_2 has several downsides, including the potential to develop resistance. Novel approaches to avoid SO_2 in managing *Brettanomyces* such as biological agents including peptides (yeast killer factors) and/or enzymes (β-glucanase) and physical method of control (low voltage, high pressure, UV treatment) will be investigated. The development of rapid/real-time sensors for *Brettanomyces* might also contribute to management of this spoilage organism.

THE IMPACT OF LIGHT ON THE OXIDATIVE AND REDUCTIVE AGING OF WINE

Project leader: Dr Andrew Clark
Researcher: TBA
Industry partner: NSW DPI

Our work has previously shown the underlying fundamental chemistry by which iron (III) organic acids, in combination with light, can initiate oxidative processes in model wine systems. In fact, it is the same underlying photochemistry that is relevant to the production of blue prints which make use of iron (III) citrate photoactivity. This process can lead to alteration of wine flavour, colour and shelf-life. Despite this work, many factors by which light can impact the oxidative and reductive development of wine are not well understood. This project will investigate the impact of light on oxidative and reductive changes in wines.

TELLING OUR STORIES

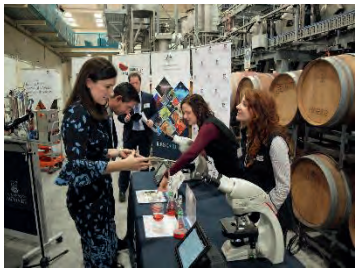
We communicate our research to academic and scientific audiences, the wine industry, our industry partners, funding bodies and research peers.

- We are eager to use every opportunity to talk about our research to various audiences.
- We travel to different wine regions and organise industry seminars.
- We conduct scientific and conference workshops.
- We use our website to inform peers and the public about new publications and Centre activities.

LAUNCH OF THE NEW TC-IWP

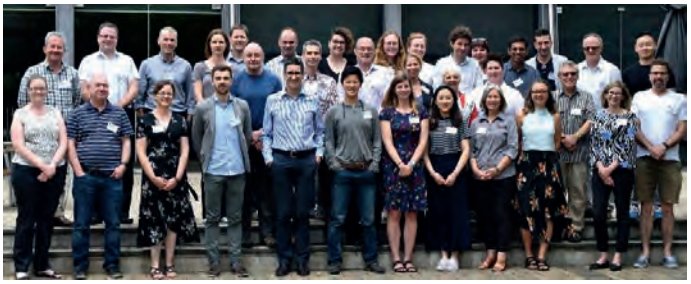
The new ARC Training Centre for Innovative Wine Production was launched by the then Minister for Education and Training Senator Simon Birmingham at the Waite campus on June 6th 2018.

Training Centre Director Prof Vladimir Jiranek, Senator Simon Birmingham, Federal Member for Boothby Ms Nicolle Flint, ARC Chief Executive Prof Sue Thomas and University of Adelaide Vice Chancellor Prof Peter Rathjen at the launch.



CENTRE-WIDE WORKSHOPS, CONFERENCES AND INDUSTRY SEMINARS

Adelaide, 1 November 2018



The first Centre workshop provided opportunities for students and post-docs to meet the team and introduce their projects. The afternoon session titled 'Collaboration: Experience and Expectations' included presentations from funding bodies, industry partners, staff and ex-students.

Adelaide, 13 May 2019

Members of the Centre and industry partners meet biannually to network and present research updates.

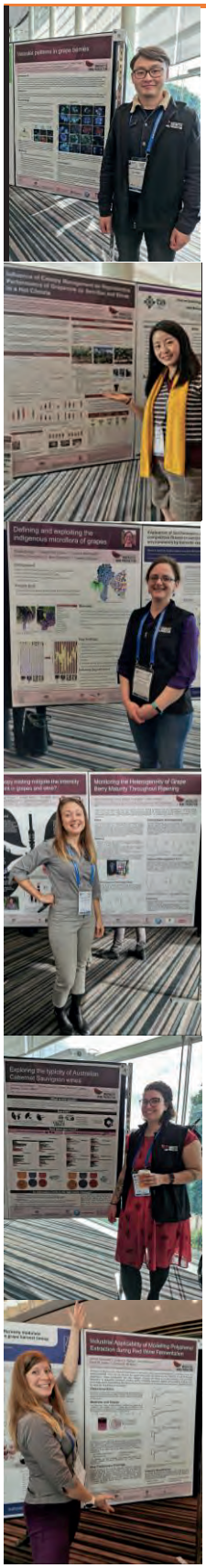
Margaret River, 15 May 2019

The Centre hosted an industry seminar in Margaret River on 15th May 2019. Among eleven presented projects the researchers talked about characterising the distinctive flavours of Australian Cabernet Sauvignon wines which included wines from Margaret River.

The production of lower alcohol wines was a key focus of the first Centre and these findings were presented in the form of an integrated strategy for modulation of alcohol levels in wines. Regional presentations are held annually and have proven to be beneficial to industry participants as well as research students who get an opportunity to receive insights and 'real-life' feedback on their project.

17th Australian Wine Industry Technical Conference (AWITC), 21-24 July 2019

TC-IWP workshop 'Exploring regional diversity in Cabernet Sauvignon', conveyed and presented by Dr Dimitra Capone, with co-convenor Sarah Pidgeon from Wynn's Coonawarra Estate, showcased important flavour and sensory attributes of selected commercial wines from four diverse wine regions (Coonawarra, Yarra Valley, Margaret River and Bordeaux). Additionally, the workshop presented results from various projects on Cabernet Sauvignon related to berry shrivel (Vinay Pagay), flavour profiles (Paul Boss, CSIRO) and managing wine alcohol levels under challenging conditions (Olaf Schelezki and Renata Ristic). Guest speakers included Andrew Caillard MW of Pinnacle Drinks, Glenn Goodall from Xanadu Wines and A/Prof Sue Bastian from the University of Adelaide.



Zeyu, Eva W., Krista, Claire, Lira and Judith presented posters at the 17th AWITC.

HIGHLIGHTS AND AWARDS

TC-IWP was a finalist in the 2019 South Australian Science Excellence Awards in the category for Excellence in Research Collaboration.

Prof Matthew Gilliham became Director of the Waite Research Institute adding this position to his other numerous roles.

Xiaoyi (Eva) Wang received an award for the best poster at the 17th AWITC.

Colleen Szeto presented "Can in-canopy misting mitigate the intensity of smoke taint in grapes and wine?"at the 3rd International Flavor & Fragrance Conference (IFFC) in Viña del Mar, Chile (1-4 October, 2019).

In July 2018 Dimi, Lira and the project team ran a one-day workshop at Katnook Estate Winery in Coonawarra which provided valuable input into the project design and selection of wines.

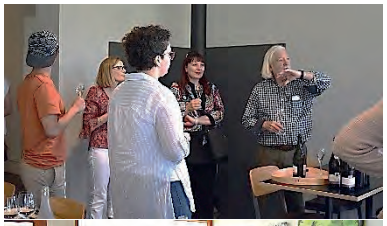
In November 2018 Dimi, Lira and the project team conducted an expert tasting of 84 commercial Cabernet Sauvignon wines from vintage 2015 selected from the Coonawarra, Margaret River, Yarra Valley and Bordeaux wine regions.

Dr Dimi Capone was invited to the 2019 Limestone Coast Wine Show (LCWS) as an associate wine judge and to speak about her project.

REGIONAL VISITS

Adelaide Hills

Viticultural and winemaking practices at Tapanappa Winery.

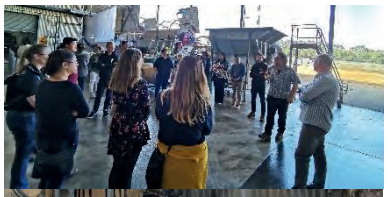


Wine tasting at Greenhill Wines with Paul and Penny Henschke.

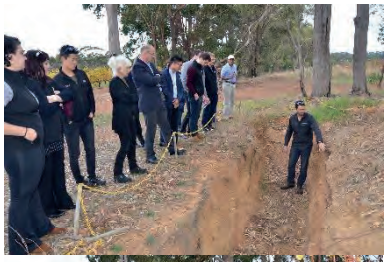
Winery tour with Alex Clark in the Shaw & Smith winery.

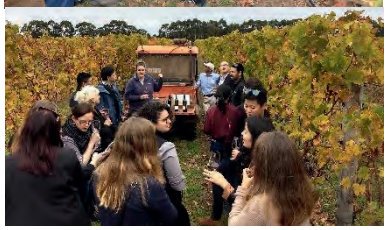
Margaret River

The Margaret River winemaking region was showcased by Dr Tony Proffitt and Charlotte Newton.



Domaine Naturaliste was presented by Bruce Duke.





Voyager Estate provided an unforgettable wine tasting in the middle of the vineyard.

Tasting of Leeuwin Estate wines with senior winemaker Tim Lovett.

Biodynamic practices at Cullen Wines.

PUBLICATIONS

Peer-reviewed Centre publications

- KM Sumby, L Bartle, PR Grbin and V Jiranek (2019) Measures to improve wine malolactic fermentation. Applied Microbiology and Biotechnology 103 (5), 2033–2051

Related publications

- V Jiranek, F. Bauer, and H. Takagi, H. (2019) Yeast Ecology and Interaction. FEMS Yeast Research, 19(8), foz073
- C Dang, KL Wilkinson, V Jiranek and DK Taylor (2019) Development and evaluation of a HS-SPME GC-MS method for determining the retention of volatile phenols by cyclodextrin in model wine. Molecules 2019, 24, 3432
- DT Pham, V Stockdale, DW Jeffery, J Tuke and KL Wilkinson (2019) Investigating alcohol sweetspot phenomena in reduced alcohol red wines. Foods 8, 491
- OJ Schelezki, G Antalick, K Suklje and DW Jeffery (2019) Pre-fermentation approaches to producing lower alcohol wines from Cabernet Sauvignon and Shiraz: Implications for wine quality based on chemical and sensory analysis. Food Chemistry 309, 125698
- S Li, KL Wilkinson, A Mierczynska-Vasilev, KA Bindon (2019) Applying nanoparticle tracking analysis to characterize the polydispersity of aggregates resulting from tannin-polysaccharide interactions in wine-like media. Molecules 24(11), 2100
- KM Sumby, J Niimi, AL Betteridge and V Jiranek (2019) Ethanol-tolerant lactic acid bacteria strains as a basis for efficient malolactic fermentation in wine: evaluation of experimentally evolved lactic acid bacteria and winery isolates. Australian Journal of Grape and Wine Research 25 (4) 404-413
- L Chen, DL Capone, EL Nicholson and DW Jeffery (2019) Investigation of intraregional variation, grape amino acids, and pre-fermentation freezing on varietal thiols and their precursors for Vitis vinifera Sauvignon blanc. Food Chemistry, 295, 637-645
- L Chen, DL Capone, DW Jeffery (2019) Analysis of potent odour-active volatile thiols in foods and beverages with a focus on wine. Molecules, 24, 2472
- AHN Nguyen, DL Capone, TE Johnson, DW Jeffery, L Danner, SEP Bastian (2019) Volatile composition and sensory profiles of a Shiraz wine product made with pre- and post-fermentation additions of *Ganoderma lucidum* extract. Foods 8, 538.
- L Bartle, K Sumby, J Sundstrom, V Jiranek (2019) The microbial challenge of winemaking: yeast-bacteria compatibility. FEMS Yeast Research 19 (4) foz040
- M Man-Hsi Lin, PK Boss, ME Walker, KM Sumby, PR Grbin, V Jiranek (2020) Evaluation of indigenous non-*Saccharomyces* yeasts isolated from a South Australian vineyard for their potential as wine starter cultures. International Journal of Food Microbiology 312, 108373

Industry articles

- S Logan (2018) Future-proofing the industry through training and innovation: New research centre to build on the Australian wine industry's competitive edge. Australian & New Zealand Grapegrower and Winemaker 654, 79-80
- R Ristic, KL Wilkinson (2019) Smoke taint in the bottle: how long will it last? Australian & New Zealand Grapegrower and Winemaker 660, 46-49
- K Wilkinson, R Ristic (2019) Understanding the effects of smoke taint on fruit and wine. Australian & New Zealand Grapegrower and Winemaker 660, 42-44
- A Deloire, A Pellegrino and R Ristic (2019) Spatial distribution of berry fresh mass, seed number and sugar concentration on grapevine clusters of Shiraz: Discussion of potential consequences for sampling to monitor vineyard ripening. Wine &Viticulture Journal 34 (2), 42-47
- C Liang, R Ristic, R Stevenson, V Jiranek and DW Jeffery (2019) ARC TC-IWP uses magnetic polymers to remove overpowering green capsicum flavour from Cabernet Sauvignon wine. Wine & Viticulture Journal 34 (4) 24-26


ARC Training Centre for
INNOVATIVE WINE PRODUCTION
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The ARC Training Centre for Innovative Wine Production would like to thank our industry partners for their valuable inputs and continuous support

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Pernod Ricard Winemakers
Open Up Our World of Wines
VAF WINE FILTRATION
WAITE RESEARCH INSTITUTE
Wine Australia

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