

ARC Training Centre for Innovative Wine Production Annual Report 2016

#### THE ARC TC-IWP



The Centre would like to gratefully acknowledge Duc-Truc Pham for beautiful photos, Anne Auricht, the University of Adelaide and Robyn Harrington, CSU, for fantastic administrative support.

This report has been compiled by Renata Ristic.



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## DIRECTOR'S REPORT

It gives me great pleasure to present the 2016 Annual Report for the Australian Research Council's Training Centre for Innovative Wine Production (ARC TC-IWP). This year covered the half-way point for the majority of Centre projects and hence the initial term of this iteration of the ARC TC-IWP. Most projects have now had the benefit of at least two vintages during which to undertake vineyard or winery-based trials. Significant research outputs, publications and industry engagement activities have been achieved.

Key publications covered topics including:

- Findings on the evaporation of ethanol from wine in glasses (Wollan et al. 2016, JAFC 64:7569–75) – work of critical relevance to the wine show judging circuit.
- The composition and benefits (or otherwise) of the use of winemaking supplements to modify wine composition and sensory properties (Li et al. 2017, JAFC 65:1353–1364).
- Effect of alcohol reduction on wine volatile composition and sensory attributes (Longo et al. 2017, JSFA 97: 8-16).
- Harvesting and blending regimes using early harvest fruit to manage alcohol content (Longo et al. 2017 JSFA 98, 33-42).

Furthermore a large number of peer-reviewed publications have been drafted or submitted and are therefore in the pipeline to appear in 2017/2018.

We were please to showcase our work and the ARC TC-IWP through conferences, industry



meetings and presentations in: Adelaide (>10x), Yarra Valley, Wagga Wagga; Stuttgart and Wartburg (Germany); Bordeaux (France); Delft (Netherlands); Verona and Perugia (Italy); Porto (Portugal); Modesto, Washington and Ithaca (USA); Shanghai and Ningxia (China), among others.

The Centre's annual workshop and industry seminar was held at the National Grape and Wine Industry Centre in Wagga Wagga attracting several wine industry personnel and media attention. The student presentations were well received with students gaining valuable feedback about their key objectives and research methodologies. Scientific presentations were accompanied by professional development sessions for our PhD students and postdoctoral fellows. A post-workshop tour of some iconic wineries in the Canberra district was highly appreciated by our mostly international cohort.

Virtually, all ARC TC-IWP personnel took part in the 3yearly Australian Wine Industry Technical Conferences held in Adelaide. As well as running a workshop on alcohol corrected wines, Centre participants contributed to several other workshops, poster presentations and short talks. The Centre was recognised through two Peoples' Choice Awards at the conference.

The Centre was also invited and hosted by the Limestone Coast Wine Industry Council in November. The interaction with Coonawarra industry was highly productive and contributed to the development of a (now successful) Centre rebid in Dec 2016. 'TC2' aims to begin Jan 2018.

The Centre continues to provide and deliver excellence in educational activities for our ICHDRs and ICPDs and will continue to maintain its training focus, whilst striving for excellence in industry-relevant research.

Professor Vladimir Jiranek

Director

## THE CENTRE

#### **Overview**

The Australian Research Council (ARC) Training Centre for Innovative Wine Production (TC-IWP) was established at The University of Adelaide in 2014. The centre is one of only four Training Centres funded in the first round of the ARC's Industrial Transformation Research Program, which is designed close to foster partnerships between University-based researchers and the industry members benefit from the research outcomes.

The TC-IWP was formed with support from industry partners and Wine Australia and links scientific and industrial expertise as contributions and facilities of the University of Adelaide, Charles Sturt University, the Australian Wine Research Institute, CSIRO, NSW Primary Department of Industries, SA Research and Development Institute, TechIn SA (formerly BioSA), Treasury Wine Estates Vintners Ltd, Laffort Australia Pty Ltd, Lowe Wines Pty Ltd, Memstar Pty Ltd, Tarac Technologies Pty Ltd and Sainsbury's Supermarkets Ltd. The centre is directed by Professor Vladimir Jiranek (UA) with the help of the TC-IWP Advisory Committee.

#### **Our mission and aims**

The Training Centre will provide new knowledge, methods and technologies as well as highly skilled PhD and postdoctoral researchers to tackle the main challenges for the Australian wine industry, such as climate warming, water restrictions, changing consumer preferences and rising wine alcohol content. Earlier grape ripening and more frequent hot weather events tend to compress vintages and lead to over-ripening and high sugar accumulation in grape berries. Over-ripened grapes lose their fresh fruit sensory profiles producing wines that can be overly alcoholic, "hot" and unbalanced.

The approach that the TC-IWP will take in order to reduce alcohol levels and enhance wine flavour profile will include interdisciplinary strategies with specific research aims in the areas of viticulture, microbiology, winemaking, wine processing and consumer studies.

The specific aims are:

- 1. Through the vineyard: curb sugar accumulation, accelerate the development of flavour compounds and minimise taint compounds in the grape.
- 2. At the winery: remove sugar prior to fermentation, divert sugar away from alcohol, improve the reliability and reduce the duration of high sugar fermentations, and enhance the sensory properties of wine.
- Post fermentation: selectively remove alcohol and develop additives to adjust levels of sensory compounds in wines from under-ripened grapes or lost from wines of lower(ed) alcohol content.
- Define current market and consumer perceptions and preferences for loweredalcohol wine and use this knowledge to inform the production process.

These topics will be addressed through an integrated whole-ofproduction-chain approach that starts in the vineyard, integrates vinification and post-vinification, and finishes with wine consumers.

#### **Facilities**

The TC-IWP has established links and collaboration with all partner organisations, whose contribution in expertise and facilities is essential for the TC-IWP research projects. The base for the Centre, the University of Adelaide's Waite Campus, is home to the Wine Innovation Cluster, which includes UA, AWRI, CSIRO and SARDI. It is one of the largest concentrations of grape and wine research facilities in the world.

The Wine Innovation Central Building is home to the ARC Training Centre and houses world-class research laboratories and other state of the art research facilities. It is also home to AWRI with SARDI and CSIRO partners located in adjacent buildings, thereby enhancing collaboration and communication opportunities and the optimum use of specialist The equipment. building, a joint \$30 million construction, was completed and opened in 2008. It has extensive facilities for vine physiology, biochemistry, molecular biology, microbiology and sensory studies as well as process testing laboratories. The University of Adelaide's Hickinbotham Roseworthy Wine Science Laboratory at the Waite Campus is a state-of-the-art winery and research facility doing valuable work for the wine industry, through education, research and service provision. Students. researchers. laboratory staff and wine industry professionals are all involved in the winemaking, in a collaboration aimed at furthering quality, knowledge, and sharing of information, not to mention turning out award-winning wines.

Wine production started in 1998 with less than 10 tonnes being processed, and now has a capacity of nearer 200 tonnes, although the annual average is currently closer to 120 tonnes. There are more than 1,000 tanks, around 100 of which hold over 200 litres. Most are for small batches to accommodate the various requirements for teaching, research, and catering industry needs. More to specialist. smaller scale equipment includes a custombuilt robotic platform.

### **PROJECTS AND RESEARCHERS**

Key Centre Personnel			
Professor Vladimir Jiranek (Director)	The University of Adelaide		
Professor Stephen Tyerman	The University of Adelaide		
Professor Dennis Taylor	The University of Adelaide		
Professor Pascale Quester	The University of Adelaide		
Associate Professor Kerry Wilkinson	The University of Adelaide		
Associate Professor Paul Grbin	The University of Adelaide		
Associate Professor Susan Bastian	The University of Adelaide		
Associate Professor Rachael Burton	The University of Adelaide		
Associate Professor Christopher Ford	The University of Adelaide		
Associate Professor David Jeffery	The University of Adelaide		
Associate Professor Roberta Crouch	The University of Adelaide		
Professor Alain Deloire	Charles Sturt University		
Dr Leigh Schmidtke	Charles Sturt University		
Dr John Blackman	Charles Sturt University		
Dr Peter Torley	Charles Sturt University		
Associate Professor Suzy Rogiers	NSW Department of Primary Industries		
Associate Professor Markus Herderich	AWRI		
Dr Paul Smith	AWRI		
Dr Keren Bindon	AWRI		
Professor Rob Walker	CSIRO		
Associate Professor Victor Sadras	SARDI		
Dr Theunes Johannes van der Westhuizen	Laffort Australia Pty Ltd		
Dr Vanessa Stockdale	Treasury Wine Estates Vintners Ltd		

CI Prof Deloire has resigned from CSU, but holds an adjuct position through which he continues to make his contribution and to supervise ICHDR students.

Lisa Rogerson replaced Debbie Barnes at the Partner Organisation Sainsbury's Supermarkets Ltd, UK. Lisa will join the Advisory Committee as an observer only.

Advisory Board 2016		Board 2016
	Professor Vladimir Jiranek (Director)	The University of Adelaide
	Professor Stephen Tyerman	The University of Adelaide
	Dr Leigh Schmidtke	Charles Sturt University
	Associate Professor Markus Herderich	AWRI
	Professor Rob Walker	CSIRO
	Associate Professor Suzy Rogiers	NSW Department of Primary Industries
	Dr Theunes Johannes van der Westhuizen	Laffort Australia Pty Ltd
	David Lowe	Lowe Wines Pty Ltd
	David Wollan	Memstar Pty Ltd
	Dr Vanessa Stockdale	Treasury Wine Estates Vintners Ltd
	Dr Lin Low	Tarac Technologies Pty Ltd
	Lisa Rogerson	Sainsbury's Supermarkets Ltd (observer)
	Herve Astier	TechInSA (formerly BioSA) (observer)
	Dr Renata Ristic	The University of Adelaide (observer)

# **RESEARCH PROJECTS**

	Projects	Researchers
1a	Optimisation of an early harvest regime – impact on grape and wine composition and quality	Olaf Schelezki
1b	Application of reverse osmosis/perstraction to wines made from grapes with different levels of maturity: chemical and sensory evaluation	Rocco Longo
2	The sugar-potassium nexus within the grape berry	Zelmari Coetzee
3a	Cell death in the berry and berry weight loss	Dr Simon Clarke
3b	Investigation of the physiological cause of grape berry cell death	Zeyu Xiao
3c	Molecular events underlying death in the grape berry	Siyang Liao
4	The biochemical response of grapevines to smoke exposure	Lieke van der Hulst
5	Programmed cell death in grape berries/communication between yeast and grapevine	Dr Shifeng Cao
6	Managing ethanol and sensory compounds by non-Saccharomyces yeasts	Ana Hranilovic
7	Cyclodextrins – an inert carbon sink for grape sugars	Chao Dang
8	Impact of high sugar content on the efficiency and sensory outcomes of un- inoculated fermentations	Federico Tondini
9	Selective and deliberative use of winemaking supplements to modulate sensory properties of wines	Sijing Li
10a	Getting alcohol content right: The compositional and sensory basic for an alcohol sweet spot	Dr Duc-Truc Pham
10b	The alcohol sweet spot phenomenon	David Wollan
11	Controlling unripe characters using molecularly imprinted polymers or specific microbials to eliminate methoxypyrazines from wine	Chen Liang
12	Large scale processing of wine components of vinification for the creation of useful product streams	Dr Ravichandra Potumarthi
13	Because you are worth it: Self-sacrifice vs. product authenticity (The case of wine)	Bora Qesja
14	Translation of 'whole of production chain' wine science research to industry outcomes	Dr Renata Ristic



# The ARC Training Centre for Innovative Wine Production



#### RESEARCH HIGHLIGHTS

#### Grape berry cell death

Vital grape berry cells are necessary for maintaining a high water content in the fruit. They promote water inflow from the parent plant, compensating for water lost to the atmosphere through the berry surface. Vital cells are also thought to retain water in the grape berry that would otherwise be drawn back to the parent plant to help satisfy the water requirements of the canopy. In the absence of vascular inflows, a lack of vital cells will decrease the fruit water content and increase the concentration of berry solutes, including sugars, therefore, resulting in wines with higher alcohol content

Cell death occurs late in the ripening process, but its onset cultivarand severity is dependent and can be influenced by biotic and abiotic factors. Warmer temperatures and elevated evaporative conditions during ripening may hasten the onset of cell death and berry water loss. The aim of this research is to characterise the role of heat accumulation and water stress on grape berry cell death.

Methods to assess water vapour efflux from plant organs with low transpiration rates are notoriously difficult, but the method proposed here entailing modifications minor to а commercially available cuvette was capable of overcoming frequently limitations encountered with small fruit and allows better thus understanding of the underlying processes driving grape berry dehydration and losses in cell vitality.

A field-portable system designed for conifer leaves was successfully modified to a labbased method to monitor transpiration rates of fruits (Figure 1). The collected data suggested that bunch shading and rainfall may counteract loss in cell vitality and rates of berry weight loss in Shiraz, but not in all instances. The complex endogenous and environmental factors that influence cell vitality will make it difficult to suggest vineyard strategies to manipulate berry shrivel (Project 3. ICPD Dr **Simon Clarke**).



Figure 1. Cuvette-based method for measuring the surface water vapour permeance of grape berries and other small fruits.

In search for rapid and objective measures of cell vitality a method based on the electrical impedance of the fruit was also assessed. Usina control. irrigated and water-deficit treated vines the data showed that water deficit berries had a more significant reduction in cell vitality during ripening, which was closely related to the lower oxygen content inside such berries. During berry development internal oxygen concentration ([O2]) decreased in correlation with berry cell death (Figure However, berrv 2). respiration rate decreased during late ripening only under water deficit. During late development stages naturally occurring produced fermentation ethanol in the berries, resulting in increased membrane permeability. Information on berry physiological responses to stresses abiotic and. importantly, to treatments ameliorate designed to them (such as irrigation and shading), will underpin

decisions in industry on whether to promote or avoid fruit growth under these various conditions (Project 3a, ICHDR **Zeyu Xiao**).

The beginning of cell death in both control and water stressed Shiraz berries corresponded to an increased level of reactive oxygen species (ROS). ROS versatile are signalling molecules that play an essential part in regulating apoptosis-like plant cell death (AL-PCD). The project aimed to assess whether mesocarp cell death in the grape berry is programmed as an apoptosis-like cell death. The project includes investigation into the temporal and spatial ROS, coordination of associated factors involved in the induction of mesocarp cell death, and the expression of ROS and AL-PCD related genes during critical stages of berry ripening. The outcomes suggested that the beginning of mesocarp cell death in both control and water stressed Shiraz berries corresponded to the increased level of ROS (Figure 3). RNA-seq analysis identified lists of candidate genes that showed differential expression in at least one of the comparisons between either three critical development stages or different treatments. It was suggested that genes VvBAG1 and VvLOXA could be linked to ROS signalling and programmed cell death (Project 3b, ICHDR Siyang Liao).



Figure 2. Structural arrangement of air space inside a grape. Dark/blue indicate thinner volume and white thicker volume



Figure 3. Image of grape berry signal of DCFDA (ROS sensor) and PI (cell death). DAF = days after flowering

Furthermore, the VvPub13 gene, transiently expressed in tobacco leaves, was observed to reduce H<sub>2</sub>O<sub>2</sub>-induced cell death by inducing genes involved anti-oxidant in responses. Consequently, more research has been conducted to document that VvPub13 in grape berries can inhibit cell death (Project 5, ICPD Dr Shifeng Cao)

Understanding key molecules and genes associated with the loss of grape berry cell vitality will underpin practical efforts to process. influence the Collecting information across genetically diverse grape cultivars that differ in their susceptibility to berry cell vitality loss and dehydration, across a range of berry wide developmental stages, and across vineyards that differ in their abiotic conditions, at a variety of scales, from microclimate to microscopic and molecular will provide important insights into grape berry cell death

# The sugar-potassium nexus

The functionality of K<sup>+</sup> and the co-transport of sugar and K<sup>+</sup> into the grape berry is not well understood or defined as yet. Therefore the aim of the project was to better understand this possible link (i.e. to determine if it is incidental or reliant) and to

determine if the sugar content in the grape berry can be decreased through altering K<sup>+</sup> amounts transported towards the grape berry. This may potentially result in lower alcohol wines due to the decreased sugar content in the grape juice at the time of harvest.

Some similarity in the accumulation patterns of sugar and K<sup>+</sup> into the grape berry was observed. but their interdependence is still not fully understood. It has been to possible successfully manipulate the accumulation of both sugar and K<sup>+</sup> into the grape berry in a tightly controlled setting, but this was not applicable on an industrial scale due to ability of the grapevine to compensate and regulate

internal processes in spite of environmental alterations. However, high K<sup>+</sup> content in Australian soils results in a high uptake rate of K<sup>+</sup> by the grapevine. While it is not feasible to decrease the K<sup>+</sup> in the soil, there is the possibility of using some rootstocks with decreased K<sup>+</sup> uptake. Whether this decline in K<sup>+</sup> uptake by the vine would result in lowered sugar accumulation into the berry remains to be tested, along with other carry-on effects on vine physiology and berry growth and flavour development. Other solutions may include the selection of varieties and rootstocks or clonal selections of widely used varieties that may uptake and accumulate less sugar in the berries (Project 2, ICHDR Zelmari Coetzee).



### Optimisation of an early harvest and blending regime

A sequential harvest regime (i.e., harvesting grapes at earlier time points) or juice substitution with a green harvest (i.e. 'wine' from unripe grapes) or water prior to fermentation can be used as a method to produce wine with a lower alcohol content (decreased up to 3% alcohol by volume) compared to commercially ripe fruit. Particularly interesting was the apparent absence of dilution effects when using water, which enabled easy moderation of alcohol levels with no or small changes in wine phenolic composition and sensory profile. This pioneering work initiated further research into optimisations of the blending techniques, which are particularly interesting for winemakers in light of recent changes in the Australian and New Zealand Food Standard regulations that now permit the pre-fermentative addition of water under certain conditions (Project 1a, ICHDR Olaf Schelezki).

The 'double harvest' method used with Verdelho and Petit promisina Verdot showed results in reducing the alcohol level in wines without significant implications for wine sensory profile. Verdelho and Petit Verdot blends maintained similar sensory composition to that of wines made from the more mature fruit (H2), despite the wines being prepared from an equal volume of wine that was made from less ripe grapes (H1). Verdelho H1 wines were characterised by 'citrus'. 'herbaceous' and 'acidity', and VH2 were associated with 'apple/pear', 'tropical fruit'. 'rockmelon', 'hay' and higher 'alcohol', 'bitterness' and 'sweetness'. Petit Verdot H1 wines were perceived higher in 'red fruit', 'green pepper', 'tomato leaf' and 'acidity', while the PVH2 wines were dominated mostly by 'dark fruit', 'black cherry', 'plum', 'black pepper', 'alcohol' and

'astringency'. The blended samples were positioned between the two harvest wines, which probably indicates that blending had resulted in an averaging effect on their chemical and sensory profiles. However, it was found that unripe sensory descriptors such as 'herbaceous' for Verdelho and 'tomato leaf' and 'green pepper' for Petit Verdot, were not detrimental attributes in the blended wines. Further studies of other varieties with a different range of alcohol levels and blending ratios would he valuable in order to further investigate the efficacy of this procedure for the production of lower alcohol wines (Project 1b, ICHDR Rocco Longo).

#### Yeast strains in ethanol management and flavour enhancement

Several selection programmes focus on finding a yeast capable of lowering wine ethanol content while enhancing, rather than lessening, its overall quality. Besides rational and evolutionary enaineerina techniques employed to expand intrinsically low diversity in ethanol yields among S. cerevisiae wine strains, these efforts encompass exploring the diversity of non-Saccharomyces yeast strains. However, the potential of non-Saccharomyces yeasts is still under-explored, so few projects have focused on evaluating the performance of non-Saccharomyces isolates in pure culture and co-culture.

Commercial non-Saccharomyces inocula were trialled during vintage 2015-16. matrix-based Marked modulations of wine sensory perception were reflective of grape harvest date with yeast inoculumapparent derived differences. Of interest was particular the increase in intensity of descriptors generally regarded as more appealing in earlier harvest wine profiles obtained by certain non-Saccharomyces co-inocula compared to an S. *cerevisiae* control. Further validation across a range of conditions is required, but at the moment non-*Saccharomyces* appear to be a useful tool for optimising the quality of wines made from earlier harvests, as might occur with efforts to modulate wine ethanol content.

characterisation Initial of Metschnikowia identified isolates that, in conjunction with S. cerevisiae, were capable of significantly lowering wine ethanol content without any apparent off-flavour production compared to the S. cerevisiae monoculture. Promising outcomes were also obtained with Lachancea thermotolerans (Figure 4). Formerly known as Kluyveromyces а thermotolerans, it is a species with remarkable, vet underexplored, biotechnological potential. This ubiquist occupies a range of natural and anthropic habitats covering a wide geographic span. To gain insight into L. thermotolerans population diversity and structure, 172 isolates sourced from diverse habitats worldwide were analysed using a set of 14 microsatellite markers. The resultant clustering revealed that the evolution of 1. thermotolerans has been driven by the geographical localisation, as well as the ecological niche of isolation. Genetic proximity of isolates originating from anthropic environments, in particular grapes and wine, was established, thus suggesting domestication events within the species. This study sheds light genotypic the and on diversity of L. phenotypic thermotolerans, contributing to a better understanding of the population structure, ecology and evolution of this non-Saccharomyces yeast (Project 6, ICHDR Ana Hranilovic).



Figure 4. Lachancea thermotolerans yeast colonies.

During fermentation yeast cells gene must coordinate expression to rapidly respond to changes and external to maintain competitive fitness and cell survival. Although, several studies have analysed the yeast response to specific stress conditions, there is a need to expand our knowledge about spontaneous, multicultural fermentations where multiple stresses are present. In this study, twenty isolated yeast strains have been tested for physiological responses to osmotic and ethanol stress. Yeast reaction to osmotic stress was clear and similar for all the evaluated strains, while ethanol stress appeared to be more challenging and the responses were more differentiated and genera/strain specific. Based on these results three wild yeast strains have been selected for analyses transcriptome to explore how different yeasts change their gene expression in response to stress conditions. Torulaspora delbrueckii shows high potential as an alternative to an S. cerevisiae monoculture during wine fermentation. This study further confirmed that T. delbrueckii produce less volatile acidity and different aromatic compounds during Furthermore, fermentation. transcriptome analyses revealed the relation between phenotype. genotype and Extended characterisation of its oenological traits will allow winemakers to use this yeast species in an informed manner as another tool to improve wine sensory profile. However, the interaction with Saccharomyces and consequently the performance of a mixed population in high sugar mixed fermentations needs to be investigated further. (Project 8, ICHDR Federico Tondini).

## Techniques for ethanol management and flavour enhancement

The use of winemaking supplements to modulate sensory properties in wine

Tannins and polysaccharides are important contributors to mouthfeel and thus, the quality of red wine. Their concentration and composition are influenced by both vineyard management practices and winemaking techniques. Use of commercial wine additives presents an easy method for winemakers to fine tune the tannin and polysaccharide composition of wine. The aim of this project is to explore to what extent commercial oenotannin and mannoprotein (polysaccharide) products can modulate the composition and sensory properties of wine. Oenotannins were chosen as they have been widely used for colour stabilisation, creating specific wine styles, masking faults and general risk management, while mannoproteins contribute to palate fullness and reduce astringency. However, there is a need for greater understanding the compositional of consequences of tannin and mannoprotein additions, including any interactions between tannins and mannoproteins. The study revealed that commercial tannin and mannoprotein products were very different in terms of chemical composition within their respective category. Some products demonstrated good agreement between the manufacturer's claim and chemical composition. i.e. skin/seed origin vs. tannin subunit composition; and mannoprotein rich vs. molar proportion of mannose residue, while others did not. Also, for some producers, products under different labels showed similar chemical composition and thus are likely to have similar effects on wine. It is therefore suggested that winemakers do bench trials with commercial tannin and mannoprotein products, rather than rely on information and claims on effects supplied by the manufacturer. This survey also identified tannin and mannoprotein products of different chemical properties that will be included in future chemical and winemaking trials to study the interactions of polysaccharide tannin and (Project 9, ICHDR Sijing Li).

## Getting alcohol content right: The compositional and sensory basic for an alcohol 'sweetspot'

Demand for reduced alcohol wines (RAW), as well as the range of treatments employed by the wine industry to reduce wine ethanol levels, has been increasing, albeit there is a lack of research on the chemical composition and sensory profiles of RAW. In general, dealcoholisation process can have complex impacts on the chemical composition of RAW. Up to now, a loss or reduction of volatiles during the dealcoholisation process was considered a major drawback of this technique. Since ethanol is essentially a solvent in wine, when ethanol level is reduced, the concentration of most nonvolatile and some volatile compounds changes. irrespective of whether or not the amount of these compounds changed. Ethanol is also directly involved in the acid-ethyl ester equilibrium so that when ethanol decreases, the concentration of ethyl esters (i.e. volatiles that positively influence wine aroma) also decrease. mav The complexity of ester interactions within the wine matrix and considering that they are present at around the detection threshold, means that modest changes in ethanol concentration might have a significant effect on wine aroma and flavour and consequently wine quality.

Following reverse osmosis– evaporative perstraction (RO-EP) treatment, obtained RAWs were found to have greater colour density and a lower concentration of ethyl esters. The RAW were perceived as less hot, acidic and astringent. The optimal ethanol level for RAW remains unclear, as well as any scientific basis for the "sweet spot" phenomenon. The expert and DA panels attempted



Figure 5. RAWs presented in a 'circle' order

to define alcohol 'sweetspot' using 'raw', 'circle' (Figure 5) and 'knockout' sensory methods with wines being presented randomly or in order (from low to high alcohol). A 'knockout' method showed promise and will be used in future trials with wine samples presented randomly and in order (Project 10 a and b, ICHDR **Duc-Truc Pham** and **David Wollan**).

# The biochemical response of grapevines to smoke exposure

The frequency of heatwaves and the incidence of bushfires is increasing all over the world. Fires occurring in close proximity to wine regions are resulting in vineyard exposure to smoke. Grapes from smokeexposed vines produce smoketainted wine, making them unsaleable. Previous research has demonstrated that smokederived volatile compounds accumulate in grapes in glycoconjugate forms i.e. with one or more sugar moieties attached. This project, therefore, aims to investigate the biochemical response of grapevines to smoke exposure; in particular, the enzymes responsible for glycosylation of smoke-derived volatiles in grapevine fruit and leaves following exposure to smoke.

Images obtained by Scanning Environmental Electron Microscopy showed inconclusive results so far on the effect of smoke exposure on berry cuticle and wax structure. Kaolinite clay was assessed on a subset of vines for its presumed protection from the smoke uptake, but no significant effect was found. However, selected smoke exposed berries have been the subject of RNA sequencing which showed promising results in identifying the upregulation of a set of glycosyltransferase genes (Project 4, ICHDR Lieke van der Hulst).

# Novel techniques for flavour enhancement

## Molecularly imprinted polymers (MPIs) to eliminate excessive methoxypyrazines from wines

A range of molecularly imprinted polymers (MIPs) and magnetic polymers (MMIPs) have been made, along with non-imprinted polymers (NIPs) and magnetic non-imprinted polymers (MNIPs) as controls to aid in the removal of methoxypyrazines from wine (Figure 6).

GC-MS analysis showed that magnetic polymers successfully removed 40-60% of IBMP (initial concentration around 30 ng/L) from model wine and white wine within ten minutes. The addition of magnetic nanoparticles and microwave induced polymerisation did not affect cavity size and adsorption properties compared to regular imprinted polymers. However, imprinted polymers could not be differentiated from nonimprinted controls under current adsorption tests, so different monomers and reaction solvents have been trialled to improve polymer specificity for IBMP. Easy separation, adsorption moderate ability towards IBMP and regeneration ability make these polymers an effective option to remediate wines elevated with methoxypyrazines and improvement of their efficiency will be a major focus of future work (Project 11, ICHDR Chen Liang).

# Cyclodextrins

Cyclodextrins, as a group of natural oligosaccharides, have been widely used in the food industry for removal of offflavours and/or modification of mouth-feel and taste. Their application is based on the ability of the cyclodextrin ring



Figure 6. Molecular template (T) of IBMP; functional monomers (M); cross-linker (C). Selfassembly and polymerisation of the system produces a rigid polymer bearing imprinted sites (1). Removal of the template through washing liberates cavities that can specifically recognize and bind the target molecule (IBMP) (2). Imprinted polymer added to wine which contains IBMP (3). Separation of the polymer results in purified wine (4). Polymer (1) may be recycled.

structure to encapsulate hydrophobic molecules in the cavity, and the physicochemical changes brought upon the guest molecules, including increased solubility, decreased volatility and decreased perception of flavour. It was found that cyclodextrins could retain some of the off-odour volatile phenols in wine, but this effect was accompanied by a loss in the volatility of other wine aroma compounds.

In this study  $\alpha$ -,  $\beta$ -, and  $\gamma$ cyclodextrins showed different specificity across the board, with  $\beta$ -cyclodextrin being the most active. It appeared that hydrophobicity of the guest molecule was a selective parameter as the compounds with more hydrophobic C-H bonds were more effectively retained than others. However, this effect was coupled with the selection of size of the guest molecule, because it was observed that compounds with branches were not encapsulated as well as those without branches in the structure. Further sensorv analysis is being carried out to

study the sensorial effect of the cyclodextrin additions. In summary, cyclodextrin polymers showed promising results, but their effect on the overall profile of the wine is yet to be determined (Project 7, ICHDR **Chao Dang**).

### Alternate product streams and blending material for managing wine alcohol

Increasing the quantity and quality of alcohol obtained from grape marc was identified as the major objective of this project. Large industry-scale trials with PO Tarac were successfully completed during vintage 2015/16 and various trials were conducted at the partner organisation in order to improve ethanol yield obtained from grape marc fermentation.

Following trials from the 2014/15 vintage, large scale experiments (5 tonne) were performed to test scalability of trial work. Furthermore, solid state fermentation (SSF), solid

liquid fermentation (SLF) and submerged fermentation (SmF) were explored and a lab scale packed column bioreactor was conceptualised, designed and fabricated for better comparison of different mixing systems. The systems were evaluated for ethanol production and cost efficiency (Project 12, ICPDF **Ravichandra Potumarthi).** 

#### The case of wine: selfsacrifice vs. product authenticity

Products are continuously innovated to improve organisation efficiency and meet consumer expectations. Although satisfying consumer expectations in a society where buyers expect continuous product improvement is imperative to survival in today's competitive environment, consumers reject 50-80% of these innovated products. While this could be due to the perceived lack of authenticity of an innovated product leading to diminished perceived value, our knowledge about the relationship between authenticity and value creation is limited. Moreover, there is no conceptual explanation specific to how consumers react when a traditional product, like wine, is intrinsically modified and how consumers' characteristics, as

well as culture moderate any trade-off between loss of authenticity and gained functional benefits. This study addresses the abovementioned gaps through the development of a conceptual framework, examining whether the intrinsic innovation of a product will elicit a stronger influence on perceived authenticity when the product is traditional rather than not traditional.

The preliminary exploratory approach, involving eleven focus groups and wine tastings, was conducted in Indonesia, where wine is not a traditional product, Australia, where wine consumption is part of the culture and France. The quantitative study was conducted in three different countries using three different stimuli. The innovation in the case of wine was related to a substantial lowering of the alcohol level.

Overall qualitative results support the conceptual model, showing that Indonesian participants are more open to consuming low/no alcohol wine and still consider the product to be wine in contrast to Australian and French participants, who reacted more negatively to the product innovation and did not consider the product to be wine. Quantitative results indicate that traditionality perceptions influence authenticity, perceptions of which in turn significantly influences purchase intention 13, ICHDR Bora (Project Qesja).





#### **RESEARCH TRAINING AND PROFESSIONAL EDUCATION**



### The Centre workshop in Wagga Wagga, NSW

The ARC TC-IWP visited grape growers and winemakers in the Canberra District wine region.

The ARC Training Centre for Innovative Wine Production, the University of Adelaide, and the National Wine and Grape Industry Centre (NWGIC) organised the whole Centre workshop in Wagga Wagga, NSW, on 19<sup>th</sup> May, 2016. The NWGIC is an alliance between Charles Sturt University, NSW Department of Primary Industries and the NSW Wine Industry Association with the mission of providing research, education and engagement with the Australian Wine Industry.



Wagga Wagga is part of the Riverina agricultural region with Griffith as the central point. It was a perfect venue for the ARC-TC IWP industry day as this region produces around 60% of wine grapes within NSW and include major producers like Casella, De Bortoli and McWilliams Wines. The Riverina region has 16 wineries and 345 wine grape producers. According to Wine Australia's 2014/2015 vineyard census, this region is also the third largest warm climate producer with 286,400t. This production comes from 18,760 ha under vines, roughly equal plantings of white and red varieties, including Shiraz, Chardonnay and Semillon.

The professional development sessions included several interesting talks about desirable attributes and traits that a PhD graduate or post-doctoral fellow should demonstrate to get a job in the academia or wine/food industry:

 Assoc. Prof. Ramudu Bhanugopan, Charles Sturt University: Desirable attributes of a PhD graduate or post-doctoral fellow entering the job market

- Dr Andrew Clark, Charles Sturt University: Remaining research active in academia
- Dr Paul Bowyer, BHF Technologies: Applying the skills, knowledge and experience of a PhD program in industry
- Prof Gifford Miller, University of Colorado: Experiences leading a highly successful research group

On the last day the Training Centre visited several vineyards and wineries, seizing an opportunity to taste some iconic wines from the Canberra wine district.



#### **Helm Wines**



Helm Wines was established in 1973 and was one of the first commercial wineries in the Canberra District Wine Region. TC-IWP had an opportunity to taste amazing Riesling and Cabernet Sauvignon wines. Helm Wines tasting room is the 1888 Toual Public School House, which is listed by the National Trust and was the inspiration for the school bell featured on its label. Ken Helm gave us an inspirational talk and tour around the winery. He and his wife Judith started the vineyard, winery and cellar door and now daughter Stephanie, a winemaker, continues as fifth generation descendants of German vinedressers from the Rhineland.



#### Clonakilla



Clonakilla was established in 1971 by John Kirk on a forty-four acre farm near the village of Murrumbateman, 40 km north of Canberra. John Kirk went into wine business after years of studying at the Cambridge University, post doctoral work at Oxford and time as a lecturer in biochemistry at Aberystwyth University in Wales. In 1968 John took a research position with the CSIRO Division of Plant Industry in Canberra. Since 1999 Clonakilla has received many 'Wine of the Year awards' earning its maker, John's son Tim, the crown of 'Winemaker of the Year'.

#### **Mount Majura Vineyard**



Mount Majura Vineyard was planted in 1988, as the first vineyard within the ACT. Today it is owned by a partnership of wine enthusiasts whose winemaking philosophy is clearly centred on respecting its unique soil and site and expressing its terroir.

# The Centre workshop in Adelaide

The Centre and Advisory Committee meeting was held on 19 November 2016 in Adelaide. This was another opportunity for researchers to present highlights of their projects in 2016 and action plans for 2017. The projects were thereafter discussed and the Annual Activity Plan for 2017 approved by the Advisory Committee.

#### **Other activities**

A two-day writing retreat was held in August 2016 in Adelaide,

while CSU organised a writing workshop for students and postdocs located in Wagga Wagga. Based on collated results, the researchers reflected on outcomes in 2016 and consequently prepared a publication plan. According to their personal goals, during the retreat they worked on figures and tables, draft publications or thesis chapters.

During 2016 the researchers participated in 141 professional short courses and workshops, some organised by the Centre and others by various organisations and institutions. As usual, statistical and chemometrics courses were very popular, as well as workshops aiming to develop scientific writing and presentation skills.

Partner Other The and organisations, such as DPI NSW, Lowe Wines, Tarac Technologies, TWE, AWRI. CSIRO and SARDI, hosted 10 postgraduate students and two postdoctoral fellows. In 2016 the researchers spent considerable time working in those organisations and acquiring skills and knowledge of an industry-based workplace.

# PERFORMANCE MEASURES



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#### Government, industry and business community briefings

The Centre research activities have been communicated to a range of government, industry and business groups by various means, exceeding targeted KPI's for end user links in all areas.

### Industry seminar in Wagga Wagga

The ARC Training Centre for Innovative Wine Production, the

University of Adelaide, and National Wine and the Grape Industry Centre organised an industry workshop 'How can we modulate flavour and alcohol levels in times of climate and market change?' at Charles Sturt University on 19<sup>th</sup> May, 2016.

The workshop was attended by 73 grapegrowers/winemakers, academics and scientists. The importance of communicating research to the industry, and the success of this workshop was covered in the local TV 'WINNEWS Riverina' and press 'The Land'. The coverage included interviews with the Centre Director Prof Vladimir Jiranek, Chief Investigator Assoc Prof Suzy Rogiers and PhD student Rocco Long



## The ARC TC-IWP attended the 16<sup>th</sup> AWITC

The ARC TC-IWP held a workshop 'Alcohol corrected wines: from production to consumption' at the 16th Wine Australian Industry Technical Conference, presenting research results and wines from several different wine production strategies, including the use of sequential harvests, non-Saccharomyces yeast strains, wine making additives and osmosis/evaporative reverse perstraction (RO/EP).

During the workshop consumer acceptance of lower alcohol wines and factors influencing their perceptions of wine quality were discussed. Whether innovations in wine can elicit a stronger influence on perceived authenticity when wine is considered traditional rather than non traditional were examined in two markets: Australia (traditional) and Indonesia (an emerging wine market). Participants were excited by the various options proposed from a vineyard and winery perspective.



Participants at the TC-IWP workshop 'Alcohol corrected wines: from production to consumption'



Researchers from the ARC Linkage project attended the workshop for real-time data collection from the participants on the wine industry's interest in adoption.

Participants at the TC-IWP workshop 'Alcohol corrected wines: from production to consumption' guessing the alcohol level in different wines

The ARC TC-IWP researchers from CSU presented the workshop 'Grapes for style: the impact of berry ripening on wine quality' and CI David Jeffery took part in the workshop 'Advances in wine flavour research'.

Aside from the workshops, 16 research projects were presented in the 16th AWITC poster session and 4 students took part in the student forum 'In the wine light'. This exciting presentation session saw 14 PhD students from all over Australia presenting their work in a fast paced format; in only 3 minutes they introduced their research as well as discussed outcomes and new prospects. ICHDR Chen Liang impressed the audience and took home the People's Choice Award, which was presented by Dr Mardi Longbottom from the Australian Society of Viticulture and Oenology.



The ARC TC-IWP also received an award for the best poster at the 16th AWITC. The People's Choice award for the best poster went to David Wollan, Duc-Truc Pham and Kerry Wilkinson for their work on changes in wine ethanol content due to evaporation from wine glasses.

After all this hard work, everybody enjoyed the conference dinner...





Chen Liang receiving the People's Choice Award for her 3-minute presentation



Bora, Lieke, Sijing and Renata (top) and Federico, Lieke, Chao and Truc (bottom) at the AWITC conference dinner

#### The Centre visit to Coonawarra wine region

In October 2016, upon invitation by the Limestone Coast Wine Industry Council the ARC TC-IWP travelled down to the South East of South Australia to present current work and discuss challenges faced by winemakers and grape growers in this area and to learn about this wine region and their beloved Cabernet Sauvignon.

On the first day of the trip we visited three wineries to get a taste of the range of wines produced in Coonawarra. Wynns Coonawarra Estate, Rymill Coonawarra and Raidis Estate provided tours of their winery, vineyards and of course, their cellar doors. The trip into the vineyard at Wynns proved to be very interesting, especially seeing the famous 'terra rossa' soil of the Coonawarra. The day ended with a beautiful meal at Chardonnay the Lodge, provided by the Limestone Coast Wine Council.



The Centre visit was covered by local newspaper 'On the Land'

On the second day all students and postdocs presented their most current research for grape growers and winemakers from the Limestone Coast region. All presentations were well received and a lively discussion about the direction of future research was the result of a couple of successful days of industry engagement for the ARC TC-IWP. Indeed, the Coonawarra Grape & Wine Inc (CGWI) will be a Partner Organisation in the



The Centre visited Coonawarra wineries and vineyards

new/extended ARC Training Centre for Innovative Wine Production which testifies to the importance of 'taking' the research directly to the industry. A local newspaper 'The Land' reported the event including interviews with the Centre director Prof Jiranek and PhD student Bora Qesja.

# International conferences

Cl Steve Tyerman and ICHDRs Zeyu Xiao, Siyang Liao and Zelmari Coetzee attended the 10<sup>th</sup> International Symposium on Grapevine Physiology and Biotechnology in Verona, Italy, 13-18 June, 2016.

10<sup>th</sup> The topics of the International Symposium on Grapevine Physiology and Biotechnology included plant and fruit development, climate change, yield, berry ripening, grape and wine quality. The session on the molecular events underlying cell death in the grape berry was of special interest to three TĊ-IWP researchers. Prof Stephen Tyerman gave a presentation 'Cell death in the grape berry' as a part of Session 1: Plant and fruit development. Zevu Xiao presented a poster 'ls oxygen deficiency the cause of cell death in grape berries?' and

Siyang Liao presented a poster 'Molecular events underlying cell death in the grape berry'. The students said that "the received feedback was overwhelmingly favourable and encouraging". They used this opportunity to introduce their projects to researchers from all over the world and to gain a understanding better of physiological and molecular aspects of grape berry cell death. One of the highlights for Siyang was a talk given by Prof Grant Cramer about transcriptomic analysis of dehydrated grapevine leaves introducing a systems' biology method for describing the correlation patterns among using R package genes (WGCNA). She is keen to apply WGCNA analysis on her season 1 data of RNA sequencing results using R project.

Zelmari Coetzee presented her current research in a poster titled 'Modifying soil potassium content and decreasing plant net carbon assimilation alter the sugar-potassium relationship in the grape berry' for which she received **a Best Poster Award** in the category 'Soil, water relations and mineral nutrition'. She said that the conference presented excellent networking opportunities and occasions to pick the brains of experts in her field of study.



10<sup>th</sup> International Symposium on Grapevine Physiology and Biotechnology, Verona, Italy, 13-18 June, 2016

ICHDRs Lieke van der Hulst and Duc-Truc Pham presented their research at the 11th Wartburg Symposium on Flavour Chemistry & Biology held in the picturesque town of Eisenach, Germany, on 21-24 June 2016. It comprised 50 oral and 65 poster presentations and was attended by 160 participants from 22 countries.

New Zealand, on the genetics behind flavour development in fruit and Dr Parker who spoke on producing smoked foods with reduced polyaromatic hydrocarbon concentrations.



Wartburg Symposium on Flavour Chemistry & Biology, Eisenach, Germany, 21-24 June 2016

In her presentation 'Impact of smoke exposure on the composition of different fruit', Lieke van der Hulst spoke about smoke taint and the chemical impact of smoke on grapes and other types of fruit. This was an opportunity for Lieke to present and discuss her work with the world scientific community and to see a full overview of the field of flavour science. Her professional highlights were the presentations by Dr Atkinson,

ICHDR **Duc-Truc** 'Compositional presented consequences of partially dealcoholised red wine' in the poster

session (photo below) and received positive and encouraging feedback. Both students agreed that Wartburg the conference provided platform а to socialize with other young researchers, while enjoying the

Pham



beautiful views the of conference location at the Wartburg Castle, UNESCO world heritage, as well as the amazing local Riesling and Pinot Gris.

Following the Wartburg Flavor Chemistry symposium in Germany, ICHDR's Lieke van der Hulst and Duc-Truc Pham attended the Macromolecules and Secondary Metabolites of and Grapevine Wine. Macrowine 2016 Conference in Nyon, Switzerland on 27-30 June. This conference focused on the understanding of the structure, evolution, role and physicochemical interactions of vine and wine metabolites and macromolecules, as well as emerging knowledge and technology in the vineyard and winery. The program had four sections including viticulture, the analysis and chemistry of macromolecules and

metabolites, the winemaking process and, glass and sensory analysis. The program comprised approximately 40 oral and 150 poster presentations and was attended by approximately 200 participants from 20 countries.

Lieke presented her field trial on the use of a protective spray for possible prevention of smoke taint in the vineyard during her oral presentation 'Impact of smoke exposure on the chemical composition of grapes', which was a part of the 'Modulators of aroma and taste' session. The received feedback from fellow researchers has been of great value for Lieke, and she got excited about possible networking opportunities outside of Australia.



Lieke van der Hulst presenting at Macrowine 2016

**ICHDR Duc-Truc** Pham presented 'Partial dealcoholisation of red wine by reverse osmosis-evaporative perstraction: impact on wine composition' in the poster session. As a chemist. Truc was interested in a range of new developments and research findings in analytical techniques for determining the composition and sensory properties of grapes and wines, which could be of great benefit to the Australian wine industry and research community.

During the Macrowine 2016 symposium all students and researchers stayed together on a location a little outside of the town of Nyon. This location was not only beautiful, but also encouraged personal and



Duc-Truc Pham in Nyon

professional socialising amongst this enthusiastic group of researchers – leading to networking opportunities for new and upcoming scientists. The Macrowine 2016 conference committee organised a tour that included

a tour that included visits to wineries and tasting at Lavaux, Geneva, an UNESCO World heritage site that covers more than 900 hectares and has more than 1000 years history of wine and viticulture. The day spent in the wine region tasting Chasselas was a great highlight!

CI Kerry Wilkinson presented 'Chemical and sensory consequences of grapevine exposure to bushfire smoke' at the 251st American Chemical Society National Meeting & Exposition, Flavor Chemistry of Alcoholic Beverages Symposium in San Diego, USA, 13-(17/3/2016) and 'Stability of smoke taint during the aging of smoke-affected wine' at the 52nd South African Society for Viticulture and Oenology Wine Tech Symposium, Cape Town, South Africa (23-25/8/2016).

In August 2016 ICHDR Lieke van der Hulst and CI David Jeffery represented the Training Centre at the 252<sup>nd</sup> American Chemical Society National Meeting held in Philadelphia, USA. David and co-authors promoted their book

<sup>•</sup>Understanding Chemistry' Wine and Lieke van der Hulst presented work on the stability of smoke taint precursors in wine. Both the book as well as Lieke's presentation were with met enthusiasm in the Division of Agricultural ጲ Food Chemistry.

CI **David Jeffery** presented 'Science behind the success of Australia's world class wines' at the College of Agriculture and Life Sciences, Cornell University, USA (23/8/2016).



David Jeffery, Andrew Waterhouse and Gavin Sacks presenting their book 'Understanding Wine Chemistry'.

ICHDR Zelmari Coetzee presented her work at the 5<sup>th</sup> International Controlled Environment Conference/AusPheno 2016, CSIRO Discovery Center in

Canberra (poster presentation) (18- 23/9/2016).

HDR **Rocco** Longo talked about how to 'Expand your career abroad: Approaching the Australian wine industry' at the University of Turin (29/9/2016).

ICHDR **Federico Tondini** presented 'Impact of high sugar content on the efficiency and sensory outcomes of uninoculated fermentations' at the *Italian Research Down Under Conference* held in Adelaide (17/11/2016). In November PDF **Renata Ristic** travelled to Germany to present 'A national initiative aimed at developing a multifaceted approach to managing alcohol and flavour' at the 62<sup>nd</sup> *German Winegrowers' Congress* held in Stuttgart, Germany, 27–30/11/2016. Renata used this opportunity to present the Centre activities to the European wine industry and to initiate further collaborations.

## Industry briefings

Besides presenting research to the worldwide scientific audience Centre researchers communicated their findings to various government and industry groups in and outside Australia:

ICPD	Ra	vich	andra
Potumarth	ni upda	updated	
industry	partner	on	trial
outcomes	(1/3/2016).		

TCD **Vladimir Jiranek** gave presentation to a Canadian delegation of the Rotary District 9500 (15/4/2016) and to the Czechoslovakian Consulate General (27/5/2016).

ICHDR Zelmari Coetzee presented 'Revisiting the sugarpotassium nexus within the grape berry' and ICHDR Olaf Schelezki talked about 'Assessment of grape ripening and size variability: Implications on wine quality and berry sorting' at the Treasury Wine Technical Viticulture Estate Team meeting, Adelaide, (2/5/2016).

CI Kerry Wilkinson presented 'Walking the line 'Getting the alcohol content right' and ICHDR Olaf Schelezki presented 'Does size matter? Berry, berry much!' at the Wine Treasury Estates Conference, Technical (10/11/2016).

After receiving the People's Choice Award for her 3-minute presentation 'In the wine light', at the 16th AWITC, ICHDR Chen Liang was invited to present her project at the ASVO Awards for Excellence Dinner (17/11/2016).

ICHDR Federico Tondini seized an opportunity to present his project 'Impact of high sugar content on the efficiency and sensory outcomes of uninoculated

fermentations' and **Ana Hranilovic**'s project 'Managing ethanol and flavour compounds by non-*Saccharomyces* yeasts' in a series of industry seminars organised by Laffort in Yarra Valley, Barossa Valley and McLaren Vale (18-24/11/2016).

ICHDR Ana Hranilovic, presented a Lachancea thermotolerans diversity study at the ISVV Grape and Wine Microbiology Group meeting in Bordeaux, (8/11/2016) and to the Biolaffort group in Bordeaux, (13/12/2016).

# Taking science to the public

ICHDR Zelmari Coetzee presented at Nerd Nite #6 on 28<sup>th</sup> April 2016 in the Union Hotel, Wagga Wagga, NSW. Started in Boston in 2003, this international event has spread around the world to over 90 cities, including Wagga Wagga. Zelmari was one of three presenters during the evening. In her presentation 'Can I thank the hole in the ozone for my fruity New Zealand Sauvignon Blanc?' Zelmari explained where the fruity characters in from. their wine originate Diverting from the usual consumption of beer at this event. she included an unexpected wine tasting, testing the skills of ordinary members of the audience in identifying the country of origin of four Sauvignon Blanc wines (from France, South Africa, New Zealand and Australia) based on the aromatic profiles of the wine.



Zelmari was answering questions from the audience while some tested their wine tasting abilities (back). To the right is Wade Kelly, Nerd Nite Wagga Wagga founder and organiser. Photo taken by the Nerd Nite photographer.

CI David Jeffery spoke about 'The science behind Australia's world class wines' during 'Pint of Science' at the Wheatsheaf Hotel, Adelaide, 24/5/2016. He also gave the talk 'The use of synthetic chemistry in wine research' at 'Science in the Pub' at the Rob Roy Hotel, Adelaide, on 5<sup>th</sup> August 2016. The talks were followed by a Q&A session with the presenter panel. There were over 100 attendees and according to the organisers "This event has been one of our most popular events to date judging from the turnout and the praise we received: SciPubWine had one of the highest attendances to date among our events. The audience certainly learned a lot more about wine and how subjective the whole experience can be".

http://www.scipubadelaide.org/ scipub-events

The Centre has also been working very hard on promoting science to various public audiences:

ICHDR Lieke Van der Hulst, Life after LIFE, video presentation for alumni study association LIFE (Life, Science and Technology), Delft Technical University. (2/2016). ICHDRs **Federico Tondini**, **Siyang Liao**, and **Lieke van der Hulst** presented their research at the AFW 10<sup>th</sup> Postgraduate Symposium in Adelaide. Lieke received an award for her presentation 'Biochemical response of grapevines to smoke exposure' (27-8/09/2016).

ICHDR Lieke van der Hulst, along with other scientists and academics, presented the Centre and AFW on many occasions such as University Open Day (12-14/8/2016), Royal Adelaide Show (8/2016), National Schools Wine Show: Wine science, flavour and aroma (10/2016) and she undertook many visits to high schools as a part of the University of Adelaide outreach program 'Why Waite'.

#### Visits to overseas laboratories and facilities

The second half of 2016 was particularly productive (and enjoyable!) for ICHDR student Ana Hranilovic. With support of the Training Centre and Wine Australia Ana flew to France in early July to spend six months at the ISVV (Institut des Sciences de la Vigne et du Vin), University of Bordeaux. The ISVV is among the world's most reputable institutions in wine and vine research, with cuttingedge work being done on wine and microbial microbiology terroir. Ana joined a highly prolific team consisting of Drs Warren Albertin, Isabelle Masneuf-Pomarède and Marina specialists Bely, in non-Saccharomyces diversity studies. Non-Saccharomyces yeasts are naturally present in the wine-related environment, but are far less studied compared to 'conventional' wine yeast that conducts wine fermentation, Saccharomyces cerevisiae. One such yeast is Lachancea thermotolerans, a species of remarkable oenological potential; as its partial fermentation can lead to

wine acidification, lower ethanol content and an increased aromatic complexity.



Marc-André Lachance and Ana Hranilovic

During her time in Bordeaux, Ana undertook a study of the diversity of a large set of *L. thermotolerans* isolates sourced from all continents and a variety of substrates, including grape fermentations from Australia, Europe and the Americas, forests in Canada and cacti in Hawaii. Some isolates showed genetic similarity based on their geographic origin of isolation, as

for example all Hawaiian isolates were quite similar at the genetic On level. the other hand. certain isolates from wine and grapes were genetically close even when isolated from distant locations e.g. samples from

Australia, Europe and New Zealand. The follow-up of this study includes attempts to select an *L. thermotolerans* strain to be used in the wine industry to help address issues exacerbated by climate change, in particular increasing wine alcohol levels and insufficient acidity. Interestingly, while attending a yeast-related conference in Italy, 2015, Ana had an opportunity to meet

Marc-André Lachance. Marc-André Lachance is an eminent Canadian yeast ecologist who can often be seen travelling to exotic destinations with his guitar and yeast isolation kit. He is also the person the studied species (and the whole genus) was named after. While staying in Bordeaux, Ana had the pleasure to interact with the European wine industry and she met a number of wine research fellows and winemakers during her studies as well as at events such as Vinitech. Tasting Bordeaux and an exquisite visit to Chateau Margaux.

In addition to attending the 10th International Symposium on Grapevine Physiology and Biotechnology Conference in Verona, ICHDR Zelmari **Coetzee** met with researchers at four research institutes. She was invited by Florian Haas to visit the Laimburg Research Institute in Ora, Italy where she presented her research in a combined seminar with the Free University of Bozen-Bolzano. This wine region is prone to high potassium in their musts so they are interested in understanding the accumulation mechanisms of potassium in grape berries.



Zelmari discussing her research with Florian Haas and Roberto Zorer in San Michele

The second visit included the La Fondazione Edmund Mach in San Michele all'Adige where she met with Diollio Porro, a nutrition expert, who introduced the use of the SPAD colorimeter as an indicator of leaf chlorophyll content and nutrition status in the grapevine.



Zelmari had an opportunity to meet with Dr Roberto Zorer who works in plant physiology and eco-physiology, viticulture and GIS modelling. She also travelled to Portugal to meet with Antonio Graça from the Associação Portuguesa para a Diversidade da Videira (PORVID). This association is working on the preservation of Portuguese grape varieties and has a large database on the clonal variation within these varieties, which is inclusive of potassium data on the concentration and pH of the juice at harvest. While in Portugal, she also took the opportunity to travel to Porto to meet with Antonio César Silva Ferreira at the Escola Superior Biotecnologia Universidade Catolica Portuguesa and discuss research relating to the grape berry cell death.

Other visits to overseas laboratories and facilities in 2016 included:

Cl **Kerry Wilkinson**, visited E&J Gallo, Modesto, CA, USA and met with Nick Dokoozlian, Tom Pugh, Bruce Pan, Ravi Ponangi, Cyd Yonker. (16/3/2016)

ICHDR Lieke Van der Hulst visited Dr. R. Hosseini and microscopy facility at the University of Leiden, the Netherlands (7/2016). TCD **Vladimir Jiranek** had a busy schedule visiting Washington State University and Prof Thomas Henick-Kling (2/7/2016); UC Davis and Prof David Block (7/7/2016); Cornell University and Prof Gavin Sacks and Dr Maria Laura Gaspar (8/7/2016) and finishing with visits to Shanghai Jiao Tong University (14/12/2016) and Ningxia University in China (17/12/2016).

CI David Jeffery visited Cornell University, College of Agriculture and Life Sciences. He met a number of staff and students. and discussed ongoing and future collaboration. During his presentation to students and staff David spoke about the Australian wine industry and activities within the TC (21-26/8/2016).

HDR **Rocco Longo** visited University of Turin, Department of Agriculture, Forestry and Food Sciences, Grugliasco (10/9/2016) and University of Turin. Department of Agriculture, Forestry and Food Sciences, Alba in Italy, (28/9/2016).

PDF **Renata Ristic** visited the University of Belgrade, Department of Horticulture and Viticulture, to discuss ongoing and future collaborations (23-24/11/2016).

# Industry visitors to the Centre

The Centre continues to attract international and domestic visitors. In 2016 ten international researches. industry and government personnel visited the Training including Centre Lynn British Bremmer, Chair Columbia Wine Grape Council; Ms Hana Flanderova, General Consul of the Czech Republic; Lisa Rogerson from Sainsbury's Supermarkets, UK: Prof Nick Dokoozlian, E & J Gallo, USA; Dr Christiane Jost, Hochschule Geisenheim University; Mike Cherney, Wall Street Journal; Claudia Brosnahan, University of Bordeaux; Daniel Durall, University of British Columbia; Greg Snell, Cypress Technologies, USA (teleconference); Benedetto Amoroso and Mauro Zuppel, AEB SPA, Brescia, Italy, and Dr Farhana Pinu, Plant & Food Research, New Zealand.

There were also 17 Australian scientists and industry visitors that spent considerable time discussing existing and possible projects including Dr Kate Howell. University of Melbourne: Darko Obradovic. Enartis: Andrew Maronic. SARDI; Geoff Weaver, Geoff Weaver Wines: Anthony Heinrich and Tony Bolzano, AB Mauri; John Reid, Redbeard Bakery; Rob Perrau, Gully Winds Wine; Thomas Leclerc, Vivelys; Greg Jackson, Tarac Technologies; David Wollan, Memstar; Matt Hooper, VA Filtration; Katie Spain, Wine Business Magazine, and Dr Jean MacInvtre from Pernod Ricard Wines.

One of the Centre's aims is to continuously look for new partners, to initiate new collaborations with both national and international partners and to build valuable relationships with new partners.

#### SPECIFIC KEY PERFORMANCE INDICATORS

# Identified new processes, products or equivalent arising from Training Centre research

#### Superior early harvest regime that delivers full flavour grapes of reduced sugar content defined

Early harvest dates can achieve wines with lower alcohol while maintaining desirable flavour in Sauvignon Cabernet and Shiraz. Blending mature fruit with extremely early-harvest low alcohol wine yielded good results but was not deemed to he particularly practical, whereas blending with water (not previously allowed when trials began but now acceptable under certain conditions) affords a very promising way to manage wine alcohol concentrations. Measures of phenolics repeated on wines from 2015 revealed that any initial differences were no longer evident after 12 months. Assessment of berry sorting by harvest date, size or content revealed sugar differences in colour and phenolic measures as a result of size and maturity, and pointed to the potential of berry sorting to optimise phenolic parameters and flavour characteristics while managing wine alcohol content. The variation in berry size and sugar content during ripening reflected vintage effects on vine performance, and further studies may reveal the utility of such berry assessments in objectively grading fruit and informing vinevard management practices or winery sorting techniques.

#### Cyclodextrins can be applied to wines faulted by "Brett" and "Smoke Taint"

Cyclodextrins, as a group of oligosaccharides based on

glucose building blocks, can be applied to wines faulted with hydrophobic off-odour aroma compounds in order to ameliorate the quality of the wine. The form of cyclodextrin application can be direct addition or polymerized cyclodextrin fining. resin However, these techniques need to be approved by the legislation authority to be formally used in the wine industry. So far, trials are being conducted to evaluate the effect of three types of cyclodextrin additions (alpha-, beta- and gamma-cyclodextrin) on wines faulted with "Brett" and "Smoke Taint". A number of compounds, including 4-ethylphenol, 4ethylguaiacol, guaiacol and other wine aroma compounds. have been proven to be with different interacting cyclodextrins. The addition of cyclodextrin also brings changes in the taste and mouthfeel of the wine, including change in perceived sweetness, acidity, and particularly, body. Polymerized cyclodextrin, if being used as a resin fining agent, will encounter much less legislative difficulty. Trials are being carried out to evaluate this method in combination with reverse osmosis techniques.

# Alcohol and/or flavour modification by microbes

Certain commercial non-Saccharomyces co-inocula were found to increase the quality and appeal of wine made from the earlier harvested fruit. Indigenous *Metchnikowia* sp. isolates capable of lowering wine ethanol content for up to ~1.5% v/v were isolated and characterised.

#### Methods for increased alcohol yields from wine and other process wastes

Largely still too early to tell. However, significant improvements have been made: 1) not adding yeast to the marc piles for seeding ethanol production can save ~\$20k pa; 2) not leaving red marc to incubate further, rather distilling it immediately may recover more ethanol and

3) to facilitate the above, red and white marc are processed separately. Also a lab-scale submerged fermentation batch bioreactor was designed and fabricated for testing to improve the process of recovering alcohol from grape marc. Pilotscale trials with the industry partner using different batches of white marc, with/without seeds or inoculation with yeast, showed small effect of removing seeds, variability of different marc batches, and up to a 3-fold increase in alcohol yield as a result of inoculation. An Honours project on quantification and assessment of vine prunings as biomass feedstock for bioethanol production revealed the significant amount of biomass generated as waste prunings in vinevards. that mild acid treatment was effective in liberating sugars, and that potential exists for using this approach to convert waste into bioethanol. However, further optimisation and technoeconomic analysis is required.

# PUBLICATIONS AND MEDIA ACTIVITIES Publications

#### **Book chapter**

Jiranek, V. and Henschke, PA (2016) Yeast Fermentation. In: Australian Winemaking. Eds N. Bullied and V. Jiranek, Trivinum Press.

#### Journal article

- Jeffery, D.W. (2016) Spotlight on varietal thiols and precursors in grapes and wines. Aust. J. Chem., 69:1323-1330.
- Wollan, D.; Pham, D-T; Wilkinson, K. (2016) Changes in wine ethanol content due to evaporation from wine glasses and implications for sensory analysis. J. Ag. Food Chem. 64:7569–75.
- Bindon, K., Li, S., Kassara, S., Smith, P. (2016). Retention of proanthocyanidin in wine-like solution is conferred by a dynamic. Interaction between soluble and insoluble grape cell wall components, J. Ag. Food Chem. 64:8406-8419.
- Li, S., Bindon, K., Bastian, S.E.P., Jiranek, V., Wilkinson, K. L. (2017). Use of winemaking supplements to modify the composition and sensory properties of Shiraz wine. J. Ag. Food Chem. 65 (7), pp 1353–1364.
- Longo, R., Blackman, J., Torley, P., Rogiers, S. Schmidtke, L., (2017) Changes in volatile composition and sensory attributes in wine during alcohol content reduction. J. Sci. Food Ag. 97:8-16
- Ristic, R., van der Hulst, L. Capone, D.L. and Wilkinson, K.L. (2017) Impact of bottle aging on smoke tainted wines from different grape cultivars. J. Ag. Food Chem. 65: 4146–4152.
- Setford, P.C.; Jeffery, D.W.; Grbin, P.R.; Muhlack, R.A. Factors affecting extraction and evolution of objective quality compounds during red wine maceration and the role of process modelling. Trends Food Sci. Techn. 69, Part A: 106-117.
- Longo R, Blackman J, Antalick G, Nielsen S, Torley P, Rogiers S, Schmidtke L, (2017) Harvesting and blending options for lower alcohol wines: A chemical and sensory investigation. J. Sci. Food Ag. 98: 33-42.
- Coetzee, Z., Walker, R., Deloire, A., Clarke, S., Barril, C. Rogiers, S. (2017) Spatiotemporal changes in the accumulation of sugar and potassium within single Sauvignon Blanc (*Vitis vinifera* L.) berries. Vitis 56: 189-195.

#### **Conference publications**

- Qesja. B., Crouch. R., Quester. P. (2016) Innovating Traditional Products "Self-Sacrifice vs. Product Authenticity", Proc 9<sup>th</sup> AWBR Conference 17-19 Feb 2016, Adelaide
- Ristic R. and Jiranek V. (2016) A national initiative aimed at developing a multi-faceted approach to managing alcohol and flavour, Proc 62<sup>nd</sup> German Winegrowers' Cong., 27–30 Nov 2016, Stuttgart, Germany.

#### Industry publications

- ICHDR Qesja. B., Crouch. R., Quester. P. (2016) Product innovation and authenticity: the case of wine', Wine and Viticulture Journal 31 (2) 67-69.
- PDF Ristic R. (2016) The ARC TC-IWP Integrated strategy for production of lower alcohol wines. Report for Wine Australia.
- PDF Ristic R, Hranilovic A, Li S, Longo R, Pham D.T, Qesja B, Schelezki O.J. and Jiranek V, (2016) Integrated strategies to moderate the alcohol content of wines. Wine & Viticulture Journal 31 (5), 33-38.
- HDR Wollan, D.; Pham, D-T; Wilkinson, K. (2016) Alcohol: Changes in wine ethanol content due to evaporation from wine glasses. Wine & Viticulture Journal, 31 (6), 32.
- The ARC Training Centre for Innovative Wine Production. Annual Report 2015.
- ICHDR L. Van der Hulst, Technical note: Smoke taint development in grapes (http://www.adelaide.edu.au/tciwp/)
- ICHDR D. Wollan, Technical note: Changes in wine ethanol content due to evaporation from wine glasses (http://www.adelaide.edu.au/tc-iwp/)
- ICHDR Z. Coetzee, Modifying carbon assimilation and soil potassium content alter the sugar-potassium relationship in the grape berry. Report for NWGIC. 12/7/2016
- ICHDR L. van der Hulst, Participation in the Wartburg Flavour Chemistry and Biology symposium in Germany and the Macrowine 2016 symposium in Switzerland - The biochemical response of grapevines to smoke exposure. Final report to AGWA. 5/8/2016
- ICHDR D.-T. Pham, Participation in the 11th Wartburg Flavour Chemistry and Biology Symposium (in Germany) & Macrowine 2016 (in Switzerland). Final report to AGWA. 12/8/2016
- ICHDR A. Hranilovic, 'Collaboration with Bordeaux researchers to explore genotypic and phenotypic diversity of Lachancea thermotolerans - a promising non-Saccharomyces for winemaking'. Report for Wine Australia 8/12/2016
- ICHDR S. Li Technical note: Use of winemaking supplements to modify the composition and sensory properties of Shiraz wine (http://www.adelaide.edu.au/tc-iwp/)

#### Media releases

- ARC TC-IWP Industrial Transformation Research Program flyer 2017 http://www.arc.gov.au/sites/default/files/filedepot/Public/Media%20&%20Resources%20Centre/flyer/ITRP\_broc hure.pdf
- \* ARC TC-IWP. Vintage Innovation. https://www.adelaide.edu.au/publications/pdfs/uni\_res.pdf. 2/2016
- ARC TC-IWP, China SA Wine Story,
- file:///C:/Users/a1066260/Downloads/China%20SA%20Wine%20Story%2024pp%20doc\_visual%2015%208%2 0(1).pdf. 3/2016
- ICHDR A. Hranilovic <u>http://research.wineaustralia.com/bursary-assists-travel-to-bordeaux-for-non-conventionalreasons/</u>. 8/7/2016
- ICHDR A. Hranilovic <u>https://blogs.adelaide.edu.au/innovative-wine-production/2016/07/15/bursary-assists-travel-to-bordeaux-for-non-conventional-reasons/</u>. 15/7/2016
- ✤ ICHDR C. Liang <u>https://www.asvo.com.au/asvo/2016-awards-dinner</u>. 17/11/2016
- 16th Australian Wine Industry Technical Conference winners announced, <u>http://winetitles.com.au/dwn/details.asp?ID=20843</u> 19/8/2016

#### **Articles**

- ICHDR C. Dang, WMB <u>http://www.wbmonline.com.au/chinese-academics-and-winemakers-trying-to-bridge-the-cultural-gap-with-australian-wines. 31/1/2017</u>
- CI K. Wilkinson, Vinlab, Smoke Taint It's Complicated! <u>http://vinlab.com/smoke-taint-its-complicated</u>. /13/8/2016
- TCD V. Jiranek, The Wall Street Journal. Winemakers Toil to Beat the Heat of Climate Change. <u>http://on.wsj.com/2cK1DyC</u>. 14/9/2016
- TCD V. Jiranek Land<http://www.theland.com.au/story/3917450/wine-industry-seeking-lower-alcoholcontent/?cs=4941> from The Land's. 22/5/2016
- Wine industry research seeking lower alcohol content. The Good Fruit & Vegetables <u>http://www.goodfruitandvegetables.com.au/story/3921421/wine-industry-seeking-lower-alcohol-content/</u> 24/5/2016
- CI D. Jeffery, Understanding Wine Chemistry, Daily Wine News. <u>http://winetitles.com.au/dwn/details.asp?ID=21071</u>. 15/09/2016
- PhD students and Coonawarra vignerons working together, Daily Wine News, <u>http://winetitles.com.au/dwn/details.asp?ID=21295</u>, 14/10/2016
- ARC TC-IWP host seminar for PhD wine industry research students, The Naracoorte Herald. http://www.naracoorteherald.com.au/story/4233797/vignerons-and-students-join-forces/ 17/10/2016
- ICHDR R. Longo http://www.advancedsciencenews.com/how-to-improve-alcohol-free-wine/. 8/12/2016

#### **Radio/TV interviews**

- TCD V. Jiranek, S. Rogeries and R. Longo, WIN NEWS, ARC-TC Symposium (Low-alcohol wine project, Wagga Wagga (NSW). 19/5/2016
- CI S. Tyerman. Lifestyle Food Channel <u>http://www.lifestylefood.com.au/articles/meet-the-famous-faces-behind-the-wine-show.aspx?platform=hootsuite.</u> 25/8/16
- ICHDR L. van der Hulst, BBC Local Royal Adelaide Show, interview on Why Waite outreach program and the smoke taint PhD research project. 11/9/2016
- TCD V. Jiranek <u>http://www.abc.net.au/radionational/programs/blueprintforliving/fermenting-food-and-drink-in-indigenous-cultures/8008526.</u> 11/11/16

## Future initiatives

Opportunities for additional researchers and collaborations are available. Interested parties should contact the Centre's director by email at <u>vladimir.jiranek@adelaide.edu.au</u>

# Summary: Key performance indicators

Key performance indicators	Target	2016
Research findings		
Number of Research outputs	26	14
Number of industry reports and publications	12	12
Number of invited talks/papers/keynote addresses	4	16
Number and nature of commentaries about the Project's achievements: Media release Articles Radio/TV interviews	4 4 3	7 9 4
End-user links	1	
Number of government, industry and business community briefings	3	21
Number of Industry visitors to the Training Centre	10	17
Number of talks given by Training Centre staff/students open to the public	6	21
International, national and regional links and networks		
Number of national and international visitors and visiting fellows	5	11
Number of national and international workshops held/organised by the Training Centre	2	4
Number of visits to overseas laboratories and facilities by Training Centre staff/students	12	17
Additional funding		
PDF support	\$125 K	\$141 K
Additional stipends and operating funds (Wine Australia)		\$70 K
Travel grants		\$7.5 K
Equipment funds		\$71 K



#### Ode to wine

Day-colored wine, night-colored wine, wine with purple feet or wine with topaz blood, wine,starry child of earth, wine, smooth as a golden sword, soft,as lascivious velvet, wine, spiral-seashelled and full of wonder, amorous,marine; never has one goblet contained you, one song, one man, you are choral, gregarious, at the least, you must be shared. At times you feed on mortal memories;

your wave carries us from tomb to tomb, stonecutter of icy sepulchers, and we weep transitory tears; your glorious spring dressis different, blood rises through the shoots, wind incites the day, nothing is left of your immutable soul. Wine stirs the spring, happiness bursts through the earth like a plant, walls crumble,and rocky cliffs, chasms close,as song is born.

Pablo Neruda