AWRI

ANNUAL REPORT

CELEBRATING
55 YEARS OF
VINTAGE SERVICE

2010

BOARD MEMBERS

Dr J.W. Stocker AO BMedSc, MBBS, PhD, FRACP, FTSE
Chairman–Elected a member under Clause 25.2(c) of the Constitution (until 6 October 2009)

Mr P.J. Dawson, BSc, BAppSc(Wine Science)
Chairman–Elected a member under Clause 25.2(c) of the Constitution (Chairman from 6 October 2009)

Mr J.C. Angove, BSc
Elected a member under Clauses 25.2(c) and 27.1 of the Constitution (from 1 January 2010)

Mr J.F. Brayne, BAppSc(Wine Science)
Elected a member under Clause 25.2(c) of the Constitution

Mr P.D. Conroy, LLB(Hons), BCom
Elected a member under Clause 25.2(b) of the Constitution

Mr G.R. Linton, BAppSc(AppChem), GradDip(SysAnal)
Elected a member under Clause 25.2(c) of the Constitution

Mr B.M. McKinnon, BAgSc (Oenology)(Hons)
Elected a member under Clause 25.2(c) of the Constitution

Ms J.S. O'Connor, BEd (PE)
Elected a member under Clause 25.2(b) of the Constitution

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

Mr J.A. Lumbers BSc(Microbiol); Lit B(Public Policy)
Elected a member under Clause 25.2(c) of the Constitution

Professor I.S. Pretorius, BSc(Hons), MSc, PhD
Ex officio under Clause 25.2(a) of the Constitution as Managing Director of the AWRI

THE COMPANY

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

The Constitution of The Australian Wine Research Institute Ltd (AWRI) sets out in broad terms the aims of the AWRI. In 2006, the AWRI implemented its ten-year business plan *Towards 2015*, and stated its purpose, vision, mission and values:

Purpose
To contribute substantially in a measurable way to the ongoing success of the Australian grape and wine sector

Vision
To deliver high value to the Australian grape and wine sector through world-class research and integrated solutions and to provide thought leadership to the research activities of the Australian wine sector

Mission
To underpin our world-class research and integrated solutions with:

» a tenacious pursuit of understanding;
» the development of a unique, extensive and usable knowledge base; and
» a focus on contributing substantially to stakeholders achieving their needs.

AWRI's values provide guidance in how it will deliver on its mission. These *values* are:

» scientific integrity and excellence;
» a culture of delivering results;
» internally and externally collaborative;
» accountability and transparency; and
» focused on the Australian wine sector and industry driven.

The AWRI's laboratories and offices are housed in the Wine Innovation Central Building of the Wine Innovation Cluster (WIC). The WIC is located within an internationally renowned research cluster on the Waite Precinct at Urrbrae in the Adelaide foothills, on land leased from The University of Adelaide. Collocated in the Wine Innovation Central Building with the AWRI are grape and wine scientists from The University of Adelaide and the South Australian Research and Development Institute. The WIC includes three buildings: WIC East, WIC Central and WIC West. WIC West accommodates the other member of the WIC concept: CSIRO Plant Industry.

Along with the WIC parties mentioned, the AWRI is clustered on the Waite Precinct with the following research and teaching organisations: Australian Centre for Plant Functional Genomics (APFG), Australian Genome Research Facility (AGRF), Australian Grain Technologies (AGT), Australian Wheat Management, BiometricsSA, three divisions of CSIRO, Department of Water, Land and Biodiversity Conservation, Primary Industries and Resources South Australia (PIRSA), Membrane Transporter Expression Facility, VivoPharm, Lifeprint and The University of Adelaide's *School of Science* (which includes the Schools of Agriculture and Wine, and Earth and Environmental Sciences).

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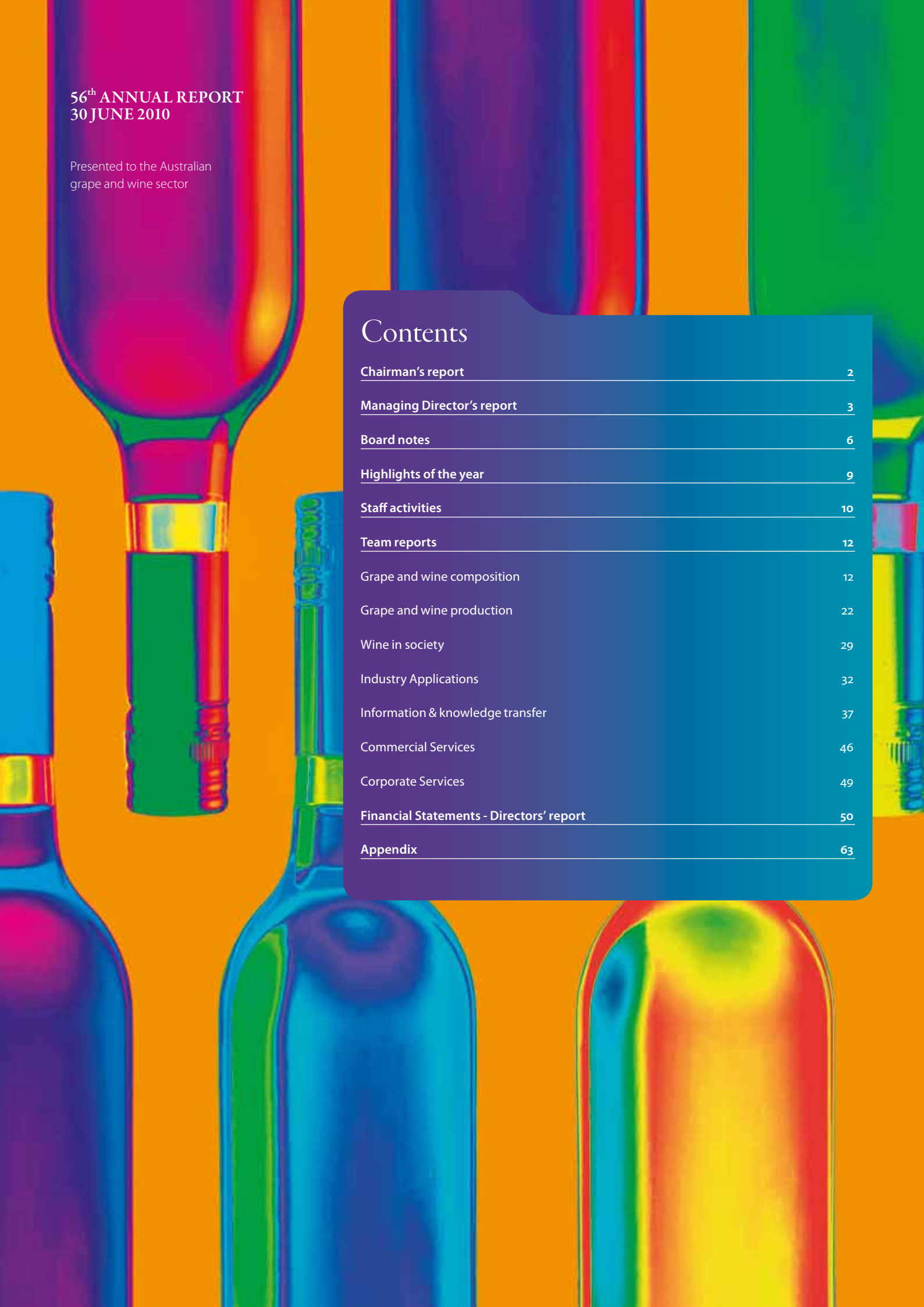
For the cover this year we've taken inspiration from the major art movement which began in the same decade as the AWRI: Pop Art! Specifically, the artworks of Andy Warhol in that era and his use of strong colour and repeating imagery. Pop Art has had a lasting influence up to the present in the art world, much like the AWRI and its continuing influence in winemaking and wine sciences.

The positioning of the bottles symbolises the interlocking symbiotic nature of the the wine industry and its partnership with the AWRI. Five vintages align with each of the 11 bottles (apart from the first one), so that the dates are presented in a digestible number and encourage the reader to back-track over to the back cover to the very origins of the AWRI.

The interlocking bottles continue off the page after 2010 which symbolises the strong relationship of the wine industry and the AWRI moving forward into the future.



56th ANNUAL REPORT 30 JUNE 2010

Presented to the Australian grape and wine sector

Contents

Chairman's report

It is with pleasure that I present to you my first report as Chairman of The Australian Wine Research Institute. Having been an elected member of the Board for the past eight years, I am proud of the AWRI's achievements over that time and my involvement in them; however, stepping into the role of Chairman in October 2009 has given me a new perspective of the organisation.

I would like to begin by acknowledging the contribution of our immediate past Chairman, Dr John Stocker AO. While his time with us was brief, the AWRI benefited greatly from his corporate and scientific experience and his wise guidance and counsel. John is a great supporter of the AWRI and we hope he might again be able to be involved with the organisation, in some capacity, in the future.

One of the main projects the AWRI has been working on in the past six months has been an internal review of our 10-year Business Plan. In 2005, the AWRI prepared a Business Plan with the input and support of Australian wine industry organisations and stakeholders. The recent review coincided with the half-way mark of the plan's duration. It was an opportunity to look back on the progress made thus far, celebrate the successes (articulated in this and prior annual reports) and reorientate the plan according to changing industry circumstances.

The Business Plan is a comprehensive document and the mid-term review, rather than 'reinventing the wheel', was focussed on the key projects articulated in the Plan, with the aims of:

» assessing the progress of the key projects;

» identifying which projects needed to continue; and

» identifying whether any new projects should be created in order to address current and emerging challenges.

The review was conducted over many months and involved the AWRI Executive Management Group and a large cross-section of AWRI employees in a series of strategic planning sessions. The outcome of the review has been to identify a series of either new or continuing projects, which were considered and approved by the AWRI Board in June 2010. The projects cover topics such as:

» communication of the outcomes of AWRI's current RD&E activities, highlighting the impact and value created through the seven-year RD&E plan;

» preparing and securing funding for a long-term RDEC Plan when the current Plan (and associated Investment Agreement) expires;

» people and culture;

» further developing the collaborative network;

» stakeholder relations and engagement; and

» leveraging maximum value for producers from the AWRI's unique RDEC business model.

The 2009/2010 year marked the fourth year of the seven-year Investment Agreement and RD&E plan framework between the AWRI and the GWRDC. The AWRI acknowledges the fundamental importance of this partnership – unlike most other research organisations, the AWRI does not have any other source of recurrent funding.

It is appropriate to acknowledge the value that this seven-year framework has brought to the AWRI, the GWRDC and the broader Australian grape and wine sector – in addition, of course, to the value generated through the 47 RD&E projects funded under the Agreement as outlined in the AWRI's seven-year RD&E plan.

» It continues to strike the right balance between long-term commitment and short-term flexibility on RD&E priorities. It provides a consistent, stable framework for all stakeholders while operating under the control of the Australian industry, specifically, levy payers.

» It has allowed the AWRI to undertake the necessary longer-term projects with confidence, greater scope and greater potential returns.

» It has allowed the AWRI to maintain, develop and assure succession of human capital, including an enhanced ability to attract the very best minds for the long-term benefit of our industry.

» It has facilitated an efficient allocation of resources into activities of relevance to the industry rather than in administrative matters (such as those associated with the writing of annual grant proposals), allowing the AWRI to deliver greater outputs per dollar of industry investment.

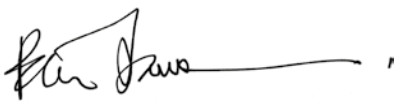
» It provides a stable operating platform for the AWRI – and a mark of confidence in the AWRI by the Australian wine industry – upon which third-party investment in grape and wine RD&E from domestic and international partners has been, and continues to be, sourced.

» Having a publically-available long-term RD&E plan has made it easier to communicate the AWRI's RD&E projects, facilitating a greater degree of domestic and international collaboration.

» Through a rigorous reporting framework, it provides the GWRDC with more regular, detailed information than under any prior framework. This provides an opportunity for both the AWRI and the GWRDC to review continuously the progress on each project.

Importantly, the framework has allowed the AWRI to maintain and enhance its position as one of the world's premier grape and wine RD&E organisations, adding status and value to the Australian wine industry as a world leader in innovation. Furthermore, it enables the AWRI to fullfil its role as a pivotal contributor to regulatory, environmental, social and technical matters that impact the daily operations of producers all over Australia. I encourage you to read the 2010 Annual Report and update your knowledge of our current work.

In closing I would like to thank my fellow Board members and in particular our Managing Director, Sakkie Pretorius, for their support and assistance in my new role as Chairman. I also extend my thanks to our dedicated staff who consistently produce world-class outputs for the benefit of the Australian grape and wine sector. The AWRI celebrated its 55th anniversary this year, and it is with this hindsight and with our resources, industry support and plans firmly in place that we can be positive of delivering what industry needs. I look forward to working with the Board, management, staff and stakeholders in the coming year.



Peter Dawson
Chairman

Managing Director's report

It has been a year of tough decisions. In response to the economic downturn and a global oversupply of wine, Australia's wine sector acted decisively. The move to reduce production marked yet another tipping point in the history of Australian wine. It also had far reaching consequences for Australian grape and wine producers.

At the AWRI, we also took decisive action. We recognised the need to use our expertise as a world-leader in wine research to support Australian grapegrowers and winemakers through one of their toughest periods in history.

We saw the need, more than ever, to 'bridge the gap' between scientific discoveries and commercial outcomes. We made it our mission to find new ways to deliver value in pursuit of profitability for our sector as a whole. We remained resolute in our commitment to building a sustainable future, both environmentally and economically, for Australian wine.

It was also a year to take stock of our position. This year marked the halfway point in the AWRI's 10-year Business Plan and its 7-year Research, Development & Extension (RDE) Plan. We undertook a thorough review of our progress and our performance remains on track: our Board, led by industry, has commended the AWRI for its achievements.

Nevertheless, we have revised our objectives, to ensure our plans remain aligned with industry priorities. This year, as we sought new ways to respond to the challenges faced by our sector, we also marked our 55th year as Australia's 'engine room' for wine research. As we acknowledge this significant milestone for our staff, our stakeholders and our sector as a whole, we took a moment to recall the history of wine research – spanning several thousand years – and consider our current challenges in a wider, global, historical context.

Making history

It is not the first time that wine producers have faced seemingly insurmountable difficulties. The history of our sector is littered with droughts and gluts; shifting preferences and emerging technology.

This year's celebration of the AWRI's 55th anniversary offered an opportunity to see that milestone as one of many along the road of wine research and development: a road that has taken thousands of years to navigate, in historical terms, with groundbreaking results.

Today's innovation become tomorrow's tradition all too quickly. If we take a moment, however, to grasp how far and how fast we have come, the relationship between scientific discovery, technological advance and progress in grape and wine production reveals a common theme dominating the past, present and future of wine.

In his 'Race for Space' speech in 1962, President John F. Kennedy's famously condensed 50,000 years of recorded human history into a time span of half a century. If we apply the same approach to the history of wine, we encounter an outstanding record of research, development and sustained innovation: breathtaking in speed, it is a story of resilience, persistence and the unwavering pursuit of opportunity.

Innovation: a time-honoured tradition

As we consider recorded human history, condensed into just 50 years, we know very little about the first 40. What we do know is that humans emerged from their caves about ten years ago. They established agriculture and the first great civilization in Mesopotamia around the Tigris-Euphrates river system.

Seven years ago, between what is now known as the Black and Caspian Seas, humans started to gather berries from wild vines in the forest. They used the seeds to cultivate vines in their villages to provide a convenient source of food. The accidental fermentation of a mixture of water and perishable grape berries in sunlight produced their first storable drink — a pleasurable drink preserved by alcohol. As we know from the discovery of Stone Age wine jugs, the intentional fermentation of grapes began soon after.

Just five years ago, humans learnt to write, to propel a boat with paddles and use a cart with wheels. One outcome was the spread of domesticated *Vitis vinifera* vines. Eventually those vines spread from Europe as far afield as India and China.

When Christianity began just two years ago – on our condensed timeline – the connection between religion and wine was already strong. The first 'miraculous sign' to be described in the scriptures involved turning water into 'choice wine' for the guests at a wedding in Cana. But wine was not only embedded in religious ceremonies: it had become an integral part of many cultures, used as a source of nutrition and as a 'social lubricant' for celebrations.

A year ago, Babylonian, Greek and Roman mathematicians, astronomers and philosophers, such as Pythagoras, Herodotus, Plato, Aristotle, Ptolemy, Copernicus and Galileo became convinced that the Earth was a sphere within a larger sun-centered universe. They started to map the world.

Such maps enabled seafarers from Spain, Portugal, Holland and England to set sail for undiscovered lands. Thanks to the preservative power of alcohol, the only storable drink on the long and dangerous expeditions of Da Gama, Dias, Columbus, Van Riebeeck, Drake, Cook and others was wine.

It comes, therefore, as no surprise that these explorers planted *Vitis vinifera* vines wherever they set foot ashore, marking the humble beginnings of wine production in the Americas, Japan, southern Africa and Australasia during the second half of last year.

This year, the Dutch merchant, Antonie van Leeuwenhoek, used a primitive light microscope to observe and describe the first yeast cells — the same cells that the French biochemist, Louis Pasteur, isolated as pure cultures a few weeks later.

Pasteur also identified them as the agents responsible for the conversion of grape sugar into wine alcohol and carbon dioxide. Inspired by these discoveries, the German enzymologist, Edward Büchner, was quick to find that this fermentation process was catalysed by enzymes contained in the fermenting yeast cells.

Meanwhile, the German oenologist, Hermann Müller-Thurgau introduced the concept of inoculating wine ferments with specially selected pure yeast cultures from a species now known as *Saccharomyces cerevisiae*.

Müller-Thurgau also demonstrated that bacteria – the malolactic bacterium now known as *Oenococcus oeni* – and not yeast, was responsible for the reduction of malic acid. This is now known as malolactic fermentation, where malic acid is converted to lactic acid in red wine and some white wine styles.

Less than six months ago, the world's growing wine industry benefited immensely from the arrival of new forms of transport such as steam-powered locomotives, bicycles, fuel-driven automobiles, tractors and airplanes.

Managing Director's report

It also benefited from new forms of communication in the form of printing, telephones and telegraphs. Artificial light and power literally cast new light on scientific discoveries and there were leaps forward in automation, introducing wineries to glass bottle-making machines, harvesters and cooling systems.

There was disease control with broad-spectrum fungicides and pesticides. There were new and stronger materials with trellising, stainless-steel pumps, pipes and fermentors. There was new packaging with novel bottle-closures and casks. Science had come into its own.

Last month – on our timeline – James Watson and Francis Crick revealed the double-helix structure of DNA. This led to the unravelling of the universal genetic code.

Last week, shortly after we developed computers and landed the first man on the moon, we learned how to clone DNA and engineer the genetic blueprint of any living cell. Only yesterday, search engines allowed us to explore terabytes of information from our newly-developed lap-top computers, wireless hand-held devices and smart phones.

This morning, we decoded the entire genetic blueprints of a human, a few animals, plants and microbes. We also decoded the Pinot Noir vine variety, one wine yeast strain and the malolactic bacterium. Equipped with this new information, we believe that by this afternoon we will be able to develop disease-resistant grapevine clones, low-alcohol yeasts and flavour-enhancing malolactic bacteria.

In the past few minutes, we achieved a breakthrough in synthetic biology. For the first time, scientists successfully transplanted a synthesized genome into a recipient bacterial cell. This marked a world first: an artificial genome, created by computer, giving life to another living being with no ancestor. The potential for future advances in genomic technologies seems endless.

Meanwhile, by midnight tonight, we also believe that, backed by human genomic data, wine market developers will have deeper insights into taste profiles of specific consumer groups. This will allow them to better align the composition of their wines with the taste preferences of their target markets.

Team AWRI: achievements in real time

Since our foundation 55 years ago – in real time – the AWRI has strived to contribute, consistently, to this breathtaking pace of research, development and innovation. This year was no exception.

The AWRI offered new knowledge, for example, in the form of a new test or assay, to help grapegrowers and winemakers affected by smoke taint. In the past, smoke taint detection has relied on testing for a compound called guaiacol, even though other phenols can also lead to smoke taint aromas in grapes as well as wine. By investigating and tracking these phenols and their non-volatile precursors, the AWRI developed new assays, offering grape and wine producers the information they need to flag the possibility of smoke taint early on.

In parallel, researchers at the AWRI have also revealed another source of the 'ashy' taste commonly attributed to smoke taint. Rather than a taste, researchers have discovered that the flavour is, in fact, an aroma, experienced when enzymes in the mouth activate non-volatile precursors and make them volatile, causing them to be sensed retro-nasally, i.e. smelled at the back of the nose.

Breakthroughs in genetic sequencing, which began 'this morning', according to our condensed timeline, also gathered pace in 2010. Researchers at the AWRI continued to build on previous work which cracked the genetic code of one wine yeast to sequence other yeasts, for comparative purposes.

As part of this work, researchers at the AWRI unravelled the genetic codes of four more strains of wine yeast as well as two beer strains. The outcome is valuable for wine researchers and producers, who seek a greater understanding of the relationship between sensory properties and yeast DNA. In the past, limited access to comparative

2020/Midnight	Market developers will have deeper insights into the exact taste preferences of specific consumer groups
2011-2019/By evening	Disease- and pest-resistant grapevines, low-alcohol yeasts and flavour-enhancing malolactic bacteria will be developed
2010/Five minutes ago	For the first time, scientists synthesised an entire genome of a bacterium and transplanted it into another bacterial cell
2000s/This morning	Genetic blueprints decoded, including the genomes of the Pinot Noir vine variety, wine yeast and malolactic bacteria
1990s/Yesterday	Search engines made it possible to explore terabytes of information on the internet
1960s-1980s/Last week	Scientists learnt how to clone DNA, engineer genetic blueprints of living organisms
1940s-1960s/Last month	Discovery of antibiotics and the double-helix structure of DNA, elucidation of the universal code, desk-top computers
1800s-1940s/Six months ago	Lightbulb, public electricity supply, new forms of transport, communication, automation, and agricultural practices
1600s-1800s/This year	Yeast cells first observed; living *Saccharomyces cerevisiae* yeast cells identified for conversion of grape juice into wine
1400s-1800s/One year ago	Maps were charted; European explorers planted vines in the Americas, Japan, southern Africa and Australasia
1000s-1500s/1.5 years ago	The Earth was regarded a sphere within a larger sun-centred universe
Birth of Christ/Two years ago	Christianity started; wine considered an integral part of religious ceremonies/within cultures as a source of nutrition
5000BC/Five years ago	Humans learnt to write, to propel a boat with paddles and use a cart with wheels. Cultivation of *Vitis vinifera* vines.
7000BC/Seven years ago	Planting of the first grapevines and making the first wines between the Black and Caspian Seas
10000BC/Ten years ago	Humans emerged from their caves and established agriculture

(LtoR) Dan Johnson, Vince O'Brien, Hans Muhlack, Sakkie Pretorius, Markus Herderich, Peter Godden, Con Simos

genetic codes has left us unable to compare one wine yeast against another and work out which mutation could be responsible for which sensory characteristic. This new knowledge provides us with deeper understanding of yeast genetics.

The AWRI also continued its efforts to develop new technologies that meet the priorities of grape and wine producers and facilitate the transfer of new scientific discoveries to vineyards and wineries.

In a world-first, the AWRI, in collaboration with producers, developed a simple labelling device which informs consumers of the 'style' of an Australian Pinot Grigio or Pinot Gris wine. Called the *PinotG Style Spectrum*, the label indicates to consumers whether the style of the Pinot Grigio or Pinot Gris wine is 'crisp' or 'luscious' or somewhere on the spectrum of possible styles in-between.

The AWRI's web portal for tannin measurement was rolled out for this year's vintage and proved itself to be a useful and reliable tool. Easy to use, in combination with a range of spectroscopy instruments commonly used in wineries, the measurement technology delivers reliable results fast. Not only can winemakers find out more about tannin levels in their wine; they can see the results in comparison with regional and national measurements. An information campaign is now underway through the AWRI's extension programmes, to raise awareness of the importance of tannin measurement, alongside traditional measures for pH, sugar and alcohol, for the assessment and prediction of wine quality. The BevScan and Phenolics web portals also passed the prototype stage this year and are currently undergoing internal testing, pending a launch through the AWRI's Commercial Services.

The AWRI also demonstrated its continued support for responsible wine drinking through its research into reduced-alcohol wine production. Since many producers remain concerned about the high export tariffs attracted by wines with higher levels of alcohol, the AWRI's research in this area contributes to economic as well as consumer health.

As part of its work in this area, researchers at the AWRI developed a prototype strain of wine yeast which produces lower-alcohol. The novel yeast has the capacity to reduce alcohol levels in Chardonnay and Shiraz from 15.5% to 12%. The GM yeast will not be released or marketed, but will now be used in laboratory environments as a reference point. This GM yeast assists researchers as they seek to develop yeasts that share the similar characteristics, but are produced using non-GM methods.

The way forward: beyond ideas

Through its unique business model, built on dedicated programmes of research, development, extension and commercialisation, the AWRI maintained its position as a world leader in wine research this year.

As an institution, we continued to inspire our colleagues and competitors. Time and again, I was reminded by wine industry leaders and researchers in Europe and North America that our business model is unique – and remains the envy of the world.

This is, however, no time for complacency. We recognise the need for hard work and the need for ideas to be translated into results. Our sector needs a practical, hands-on approach from its researchers with tailored solutions delivered on time and on target.

It is my belief, as I look back over the past year – and the centuries that preceded it – that we have a firm foundation of innovation and robust research to work from.

Australia is a nation known for its resilience, persistence and pioneering character.
As leaders in wine research we share that foundation and a commitment to continue to put science to work, for the benefit of Australian wine.

Finally, I wish to pay tribute to the AWRI Board and our stakeholders for their support. I also wish to sincerely thank every member of Team AWRI whose skills, expertise, dedication, full commitment and daily work are at the core of the AWRI's ongoing success. It is a real privilege to lead such an inventive team with an unrelenting enthusiasm to discover, collaborate, deliver, support and care.

Sakkie Pretorius
Managing Director

(LtoR) Brett McKinnon, Jim Brayne, Jim Lumbers, Peter Dawson, Sakkie Pretorius, Geoff Linton, John Angove, Jan O'Connor (absent: Paul Conroy and Mark Watson)

Board notes

Chairman
At the Board Meeting held on 6 October 2010, Dr J.W. Stocker AO resigned from the Board and Mr P.J. Dawson was elected Chairman of the Board.

Alternate Directors of the Board
Mr N.P. Blieschke
Mr C.B. Ryan
Mr A.N. Sas

Audit Sub-Committee
Mr M.R. Watson (Chair)
Mr P.D. Conroy
Mr J.A. Lumbers

Remuneration and Nomination Sub-Committee
Mr P.J. Dawson (Chair)
Mr J.C. Angove
Mr G.R. Linton

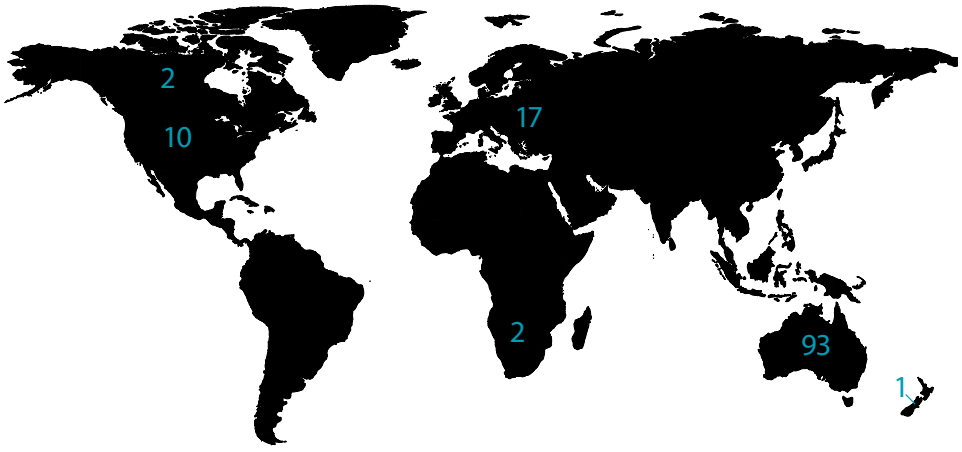
Meetings
Ordinary General Meeting
The 55th Ordinary (Annual) General Meeting was held on 17 November 2009.

Special General Meeting
n/a

Board Meetings
The Board of the AWRI met on the following dates: 21 July 2009, 25 August 2009, 6 October 2009, 9 October 2009, 17 November 2009, 23 February 2010, 1 June 2010.

Funding
The Board of the AWRI acknowledges the continuing financial support of the Grape and Wine Research and Development Corporation.

Appreciation
The activities at the AWRI benefit from collaborations from individuals and organisations from 12 different countries: Australia (Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia), Belgium, Canada, Denmark, France, Germany, Italy, New Zealand, Slovenia, South Africa, Spain, United Kingdom and the USA. We gratefully acknowledge the assistance, cooperation and/or collaboration from our partners across the globe.



Number of collaborators in areas around the world

Staff

Office of the Managing Director

Isak Stephanus Pretorius, BSc (Hons), MSc, PhD *OrangeFreeState*, Managing Director

Daniel Luke Johnson, BSc (Hons), PhD *Flinders*, GAICD, General Manager – Business Development

Raelene Joan Blair, CertAppMgt (Mkting) *AIM*, GAICD, Communication Manager

Shiralee Joy Dodd, BA, LLB (Hons) *UAdel*, Executive Officer

Roxanne Portolesi, BSc (Hons) *UWA*, PhD *Flinders*, Project Manager – Business Development, WIC Executive Officer

Amy Rose Hill, Personal Assistant to the Managing Director

Kathryn Sarah Beames, AWITC Conference Manager

Susanne Judy Milnes, AWITC Conference Secretariat

Corporate Services

Hans Engelbert Muhlack, BEc *UAdel*, CPA, Group Manager – Corporate Services

Jeffrey Mark Eglinton, BSc (Hons) *UAdel*, IT Manager

Linda Joy Halse, BA, PostGradDip (Ind Rel) *UNatal*, HR Manager

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

Mark Raymond Braybrook, Operations Manager

Andrew George Cregan, BSc *ANU*, Dip (OH&S) *CIT*, OH&S Coordinator (concluded 30 June 2010)

Susan Louise Rock, Help Desk Officer

Michelle Tania Carter, BCom *UAdel*, HR Administrator

Pauline Jorgensen, Cert IV (Bus Admin) *TAFE SA*, Administration Support Officer

Rhonda Irene Milde, Finance Officer (retired 30 November 2009)

Anne Haworth, Finance Officer (commenced 30 November 2009)

Janice Margaret O'Donnell, Receptionist

Deborah Joy Thornton-Wakeford, Receptionist

Jeanette Fay Tooley, Administration Support

Research

Markus Johannes Herderich, staatlich geprüfter Lebensmittelchemiker (CertFoodChem), PhD *Würzburg*, Group Manager - Research

Paul Joseph Chambers, BSc (Hons), PhD *Hertfordshire*, Research Manager – Biosciences

Ian Leigh Francis, BSc (Hons) *Monash*, PhD *UAdel*, Research Manager - Sensory

Yoji Hayasaka, Dip Eng (Ind Chem) *Tokyo IT*, MPharmSc *Monash*, PhD *Yamanashi*, Manager – Waite Campus Mass Spectrometry Facility

Paul Anthony Henschke, BSc (Hons), PhD *UAdel*, Principal Research Scientist – Microbiology

James Austin Kennedy, BSc, PhD *UCalDavis*, Research Manager – Chemistry

Elizabeth Joy Waters, BSc, PhD *UAdel*, Research Manager - Biochemistry

Eveline Jutta Bartowsky, BSc (Hons), PhD *UAdel*, Senior Research Scientist - Microbiology

Anthony Richard Borneman, BSc (Hons), PhD *UMelb*, Senior Research Scientist - Biosciences

Christopher Daniel Curtin, BSc (Hons), PhD *Flinders*, Senior Research Scientist – Biosciences

David William Jeffery, BTech, BSc (Hons), PhD *Flinders*, Senior Research Scientist – Chemistry

Robert George Dambergs, BSc (Hons) *UAdel*, PhD *UQLD*, Senior Research Scientist

Peter James Costello, BSc (Hons), MSc *UNSW*, PhD *UAdel*, Research Scientist

Richard Gawel, DipEd, BSc, GradDip (Oen) *UAdel*, Research Scientist

Helen Elizabeth Holt, BAgSc (Hons), PhD *LaTrobe*, Research Scientist

Keren Bindon, BSc (Hons) *UnKwa-Zulu Natal*, MSc *Stellenbosch*, PhD *UAdel*, Research Scientist

Simon Anthony Schmidt, BSc (Hons), PhD *Flinders*, Research Scientist

Maurizio Ugliano, BSc (Hons) *Naples*, PhD *Foggia*, Research Scientist

Cristian Andres Varela, BSc, MSc, PhD *CatholicUniChile*, Research Scientist

Antonio Felipe Garcia Cordente, BSc, BSc, PhD *Barcelona*, Post Doctoral Research Fellow

Matteo Marangon, PhD, Post Doctoral Research Fellow

Dariusz Roman Kutyna, MSc *AgUniPoland*, PhD *Vic*, Post Doctoral Research Fellow

Tina Thi My Tien Tran, BScBSc (Hons) *Vic*, PhD, Technical Officer

Jason Geue, BSc (Hons), PhD *UAdel*, Research Scientist (commenced 15 July 2009)

Martin Day, BSc (Hons) *Sussex*, PhD *Nantes*, Post Doctoral Research Fellow (commenced 1 December 2009)

Dimitra Liacopoulos Capone, AssDip (Chem), BAppSc *UniSA*, Senior Scientist

Kenneth Frank Pocock, BAppSc *UAdel*, GradDip (AppSc) *UniSA*, Senior Scientist (Retired August 2009)

Cory Alan Black, PhD *Otago*, Post Doctoral Research Fellow (commenced 18 January 2010)

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Tracey Ellen Siebert, ScTechCert (Chem) *SAIT*, BSc *UAdel*, Senior Scientist

Jennifer Rose Bellon, BSc *UAdel*, Scientist

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Alexander Schulkin, BSc, *Bar-Ilan, GradDip(Oen) UAdel,* Scientist (commenced February 2010)

Patrick August-Giesecke Dimanin, Cert (Enol & Vitic) *MichState*, BSc *UAdel*, Scientist (concluded 9 September 2009)

Maria Jolanta Kwiatkowski, MSc *SilesianUniTech*, Scientist

Tangerine Parker, BSc *Flinders*, Scientist

Stella Kassara, BSc (Hons) *UAdel*, Scientist

Patricia Chaves Osidacz, BSc *StateUniCampinas*, MSc *Illinois*, Sensory Scientist

Brooke Travis, BAgSc *UAdel*, Sensory Scientist (concluded 26 February 2010)

Staff

Gayle Ann Baldock, BSc (Hons) *Guelph*, Technical Officer

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

Robyn Louise Kievit, BSc *UniSA*, BSc (Hons) *UAdel*, Technical Officer
(Maternity leave from 29 January 2010)

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(Special Leave for 12 months from 17 May 2010)

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Caroline Elisabeth Abrahamse, BSc (Hons) *UAdel*, Laboratory Technician

Heather Margaret Donnell, Administrator

Jelena Jovanovic, Research Administration Officer

June Robinson, Research Laboratory Support

Microbial Metabolomics Facility

Meagan Diane Mercurio, BSc (Hons), BTech, Coordinator – Microbial Metabolomics Facility (maternity leave from 1 December 2009)

Phillip Mercurio, BSc *NthArizona*, BSc (Hons), MSc *JamesCook*, Scientist (commenced 16 November 2009)

Jeremy Crispin Hack, Technical Officer

Casual Sensory Panel

Peter Baldwinson, Brian Beggs, Leanne Curtin, Maggie Forbes, Russell Gardiner, Jaqui Gould, Philippa Hall, Gurney Khera, Karin Nagle, Ralph Osborne, Viv Rees, Mark Werner, Fiona Woodcock

Students

Ellena Sophia Anne King, BAgSc *UAdel*, PhD Student

Nicholas Ian Warnock, BBiotech (Hons) *Flinders*, PhD Student

Gal Winter, BSc, MSc *HebUniJerusalem*, PhD Student

Etjen Bizaj, BSc *Ljubljana*, Visiting PhD Student

Rocio Gomez-Pastor, BBioChem *InstAgFoodTech*, Visiting PhD Student (concluded 26 October 2009)

Roberto Riovanto, BFoodSciTech, MAFoodSciTech *Padova*, Visiting PhD Student (concluded 20 May 2010)

Teresa Riquelme, PhD *ETSI Agronomos, Politechnic Madrid*, Visiting PhD Student

Industry Development and Support

Con Arthur Simos, BAppSc *UAdel*, MBA, *UniSA* Group Manager - Industry Development and Support

Peter Ronald Dry, BAgSc, MAgSc, PhD *UAdel*, Viticulture Consultant

Sally-Jean Bell, BSc, PhD *UWA*, GradDip (Wine Bus) *UAdel*, Senior Viticulturist

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

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

Geoffrey David Cowey, BAppSc *CSU*, BSc (Hons) *UAdel*, Senior Oenologist

Matthew Grant Holdstock, BSc *Flinders*, GradDip (Oen) *UAdel*, Senior Oenologist

Creina Standish Stockley, BSc (Hons) *UAdel*, MSc *Flinders*, MBA *UniSA*, Health and Regulatory Information Manager

Gemma Ashe West, BAgSc *UAdel*, Winemaker (commenced 18 January 2010)

Marcel Essling, BBus *UVic*, BSc *UAdel*, Viticulturist

Francesca Blefari, BBus *EdithCowan, Events and Projects Coordinator* (commenced 23 May 2010)

Sean Mathew Boden, BA *UAdel*, GradDip (Info Stud) *UniSA*, Systems Librarian

Ingrid Betty-Maud Barratt, Dip (Lib & Info Stud) *TAFE SA*, Library Technician

Anne Dorothy Lord, GradDip (Info Stud) *UniSA*, Library Technician

Emma Louise Kennedy, BSc *Flinders*, Technical Officer

Virginia Frances Phillips, Administrator

Sarah Louise Ballantine, BSc (Hons) *UAdel*, Project Officer

Claire St George, Library Assistant (concluded 6 August 2009)

Fiona Mary Taylor, Library Assistant (concluded 29 July 2009)

Industry Applications

Peter William Godden, BAppSc *UAdel*, Group Manager – Industry Applications

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Wieslawa Cynkar, BSc, PhD *Wroclaw*, Research Scientist

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Ella Margaret Clare Robinson, BA, BSc (Hons) *UAdel*, Project Manager

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Warren Keith Roget, BEng (Hons) *UAdel*, Technical Manager

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Staff

Neil Scrimgeour BSc (Hons) *Wolverhampton,* Senior Process Scientist (commenced 18 January 2010)

Simon Paul Odell, BBiotech (Hons) *Flinders*, GradDip (Oen), PhD *UAdel*, Project Officer

Oliver David Lovat, BTech *Flinders*, Project Officer (concluded 30 November 2009)

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Teegan Jean Schurgott, BAg *UAdel*, Customer Service and Marketing Manager (concluded 25 September 2009)

Alana Williams, CertII (Hosp Op) *TAFE SA*, CertIV (Japanese Lang) *VLLC*, Customer Service Officer

Andrea Francis, Customer Service Officer (concluded 30 April 2010)

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David Rolfe Boehm, BSc *UAdel*, Technical Officer

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Pamela Stepancich, BTech, BInnEnt *Flinders*, Laboratory Technician

Timothy James Gordon Reilly, BSc (Hons) *Flinders*, Laboratory Technician

Carlo Mark Congiusta, BSc (Hons) *Flinders*, Casual Laboratory Technician

Highlights of the year

1 **A special wine tasting and technology showcase for key wine industry leaders were organised to celebrate the AWRI's 55th anniversary** of supporting Australian grape and wine producers.

2 **Breakthrough in smoke taint diagnostics**. (i) New multi-analyte methods for quantification of conjugated and free volatile phenols (including phenol, cresols, guaiacol, methylguaiacol, vinylguaiacol, syringol and methylsyringol) have been developed using HPLC-MS/MS and GC-MS, respectively. (ii) Aroma detection threshold values in a red wine base have been established for volatile phenol compounds implicated in bushfire smoke taint. (iii) Aided by synthesized glycosidic precursors the release of the volatile phenol guaiacol and its role in retro-nasal smoke flavour perception has been demonstrated.

3 **In a world-first, Australian producers of Pinot Grigio and Pinot Gris wines** have access to a simple labelling device which informs consumers the 'style' of the wine in the bottle at point of sale or before opening. Called the *PinotG Style Spectrum*, the label indicates to consumers whether the style of the Pinot Grigio or Pinot Gris wine is 'crisp' or 'luscious' or somewhere on the spectrum of possible styles in-between. Additionally, the labelling device will potentially help remove the confusion which results from the common use of the two names for the same variety, which are often difficult to relate to the style of the wine in the bottle.

4 **Improved understanding of the formation of tropical fruit aromas during winemaking** through the development and application of an HPLC-MS/MS method, which quantifies precursors to 3-mercaptohexanol (3-MH).

5 **Improved identification of compounds responsible for 'reductive' character**: compounds most likely associated with 'reductive' characters are hydrogen sulfide, methanethiol and dimethyl sulfide, while methyl thioacetate could act as a source of methanethiol over time. 'Struck flint' aroma in white wine may be linked to the compound benzyl mercaptan.

6 **Strong evidence links eucalyptol in red wine** to eucalyptus trees grown in close proximity to vineyards.

7 **Improved understanding of tannin** achieved indicates that (i) grape-derived cell wall materials have a stronger affinity for seed tannins than skin tannins; (ii) an increase in winemaker perception of quality is related to an increase in the concentration of tannins, particularly skin tannins in wine; and (iii) older tannins interact only weakly with proteins and this could explain the 'softening' effect that wines undergo with age.

8 **Tannin measurement went on-line** via a handy web portal, showing winemakers how to use tannin to their advantage and compare against regional and national measurements.

9 **Non-destructive analysis of wine in-bottle is now** possible through collaboration with the AWRI, Jeffress Engineering and Camo Software, using the BevScan. This technology could potentially be used to screen wine stocks to identify damaged from high quality wine due to bottling, packaging, storage or other variables.

10 **Yeast strain-derived sensory effects can be retained for long periods**. A sensory study on two sets of three year old Sauvignon Blanc wines showed that there were significant differences between wines made with different yeast strains, and these differences were retained for almost three years.

11 **Enhanced activity of two, previously uncharacterised, yeast genes** has been shown to increases the release of 3-mercaptohexanol during fermentation, increasing the pool of wine yeast genes available to improve wine flavour.

12 **A proof-of-concept, GM, wine yeast prototype strain reduced ethanol concentration** from 15.5% (v/v) to 12% (v/v) in small-scale winemaking trials in both Chardonnay and Shiraz musts.

13 **AWRI-developed wine yeast wins award in Germany**. Maurivin Platinum, a low-H_2S yeast developed by AWRI, won an award at Intervitis-Interfructa in Stuttgart, Germany, for Innovation in Processing for Wine.

14 **Genome sequences of five commercial wine yeast strains have been determined** and the data generated has highlighted what makes wine yeast different from other yeast.

15 **Alternatives to bentonite fining are gaining traction** with confirmation of the use of proteolytic enzymes to degrade haze-forming PR proteins, combined with heat treatment, can reduce the concentration of unstable grape proteins.

Highlights of the year

16 **Our understanding of red wine fruit flavours has significantly been improved** through establishment of relationships among compositional data and sensory properties from two large red wine sensory-consumer studies.

17 **Environmental web portal launched.** This allows users to search the AWRI's dedicated database of environmental articles; use the dedicated Environment Search Engine to search across multiple relevant websites related to environmental issues in one place; and to browse a range of specially-selected links clustered by topic.

18 **Confirmation that a high proportion of consumers prefer wines** with some 'green' capsicum-like flavour. Producers of Sauvignon Blanc have greater guidance regarding appropriate levels of this and the 'cat urine/sweaty' aroma particularly for Sauvignon Blanc producers.

19 **Sensory study shows split consumer preferences** for 'savoury' flavours in red wines.

20 **The WIC Winemaking Service was set up in January 2010** and has completed its first successful year of operation. The WIC Winemaking Service is a joint partnership between the AWRI and the University of Adelaide.

21 **AWRI staff members gave 320 oral presentations**, conducted 17 workshops and presented 20 posters.

22 **AWRI staff members presented 37 lectures** and coordinated the Grape Industry Practices, Policy and Communication six week subject to undergraduate students.

23 **AWRI staff members supervised**/co-supervised 21 postgraduate students.

24 **Increased requests for information serviced.** AWRI staff members responded to 5,591 recorded requests for information during the 2009/2010 year. To put the statistics into perspective, 22 people contacted the AWRI seeking information on every working day of the year. This figure does not include the amount of problem solving samples investigated (1,000) or the number of Commercial Services analyses undertaken during the year.

Readers are strongly encouraged to read the report in detail rather than relying on the brief details above for information.

Staff activities

Information on seminars, workshops, talks and poster papers given to outside organisations, academic lectures delivered, graduate students supervised, and the papers published is tabulated and can be found in Appendices 1–5 of the Annual Report. Activities in addition to those in the Appendices are described below.

Sakkie Pretorius is a member of the South Australian Wine Industry Council; the Wine Innovation Cluster Leadership Group; the Wine Industry Technical Advisory Committee (WFA); the Council of the Royal Agricultural and Horticultural Society of SA Inc.; the Wine Committee of the Royal Agricultural and Horticultural Society of SA Inc.; Editorial Board of the following journals: *American Journal of Enology and Viticulture, Annals of Microbiology, FEMS Yeast Research* and *Yeast*. He is the Chairman of the Australian Wine Industry Technical Conference Inc.; Conference Planning Committee of the Fourteenth Australian Wine Industry Technical Conference and of the National Wine Research Network (NWRN). He is a member of the International Commission of Yeasts, the Scientific Board of L'Institut des Sciences de la Vinge et du Vin (ISVV), Bordeaux, France, and the Scientific Committee of Institut Català de Recerca en Enologia I Viticultura (ICREV) Tarragona, Spain. He is also a Professor Extraordinary of the University of Stellenbosch and an Affiliate Professor of The University of Adelaide.

Dan Johnson is a Director and the Treasurer of the Australian Wine Industry Technical Conference Inc.

Markus Herderich is a Director of the Australian Wine Industry Technical Conference Inc., member of the Metabolomics Australia Executive Management Group, Industry Collaborative Innovation Program Consortium Committee and Wine Innovation Cluster Research Group. He is also an Affiliate Associate Professor of The University of Adelaide and a member of the Advisory Board of the *Journal of Agricultural and Food Chemistry*.

Eveline Bartowsky serves on the Joint Editorial Board of the *Journal of Applied Microbiology* and *Letters in Applied Microbiology* and serves on the Editorial Review Board of the *Journal International des Sciences de la Vigne et du Vin*. She is a member of The Waite Campus Health and Safety Forum, a member of the organising committee of the 11th International Symposium on the Genetics of Industrial Microorganisms (Melbourne, 2010), Poster Coordinator for the 14th Australian Wine Industry Technical Conference (2010 in Adelaide), and is an Affiliate Lecturer at The University of Adelaide.

Paul Chambers is a member of the organising committees for the 11th International Symposium on the Genetics of Industrial Microorganisms (Melbourne in 2010), is coordinator of a national, Bioplatforms Australia/AWRI, Wine Yeast Systems Biology project, and is coordinator of the Australasian Yeast Group (through its homepage at http://www.ayeastgroup.org/).

Daniel Cozzolino is a member of the honorary editorial board of the *International Journal of Wine Research*.

Bob Dambergs is a member of the Wine Industry Tasmania Technical Committee and the National Wine Research Network (NWRN).

Leigh Francis is an Associate Editor of the *Australian Journal of Grape Wine Research*, a member of the Editorial Board of the *Journal of the Science of Food and Agriculture*, and is also an Affiliate Lecturer at The University of Adelaide.

Jeremy Hack is a member of the Metabolomics Australia Analytical, Laboratory Information Management System (LIMS) and Informatics working groups.

Paul Henschke serves as an Associate Editor of the *Australian Journal of Grape and Wine Research,* is a member of the Editorial Review Boards of *Food Microbiology* and *Mitteilungen Klosterneuburg*, and was a member of the local organising committee for the Australasian Yeast Group Symposium held in Adelaide in December 2009. He is a guest lecturer at The University of Adelaide and Flinders University.

James Kennedy is an Associate Editor of the *American Journal of Enology and Viticulture*, and a Contributing Editor for *Practical Winery and Vineyard*. He is an Affiliate Associate Professor at the University of Adelaide, and is also a Courtesy Associate Professor at Oregon State University.

Meagan Mercurio is a member of the Metabolomics Australia analytical working group.

Simon Schmidt is a member of the Australian Society of Biochemistry and Molecular Biology (ASBMB) and ASBMB liaison officer for the Adelaide Protein Group (APG) Organizing Committee.

(LtoR) Debra Thornton-Wakeford, Jan O'Donnell, Jeannette Tooley, Amy Hill

Elizabeth Waters is an Associate Editor for the *Journal of Agricultural and Food Chemistry*, an Affiliate Associate Professor, The University of Adelaide and an Adjunct Professor, National Grape and Wine Industry Centre, Charles Sturt University. She is a Director of Provisor Pty Ltd, a member of the Scientific Committee for Macrowine2010 (Turino, Italy, June 2010) and In Vino Analytica Scientia (Angers, France, July 2009), an Academic member of O2inWines™, a member of the International Scientific Committee of the *Journal International des Sciences de la Vigne et du Vin* and an Expert member of Performance BIB.

Peter Godden is a member of the 14th Australian Wine Industry Technical Conference Planning Committee and the Program sub-committee, and was Vice President of the Australian Society of Viticulture and Oenology until November 2009. Peter participated as a panel chair at the 2009 Victorian Wines Show.

Con Simos is a member of the Wine Industry relations committee, the 14th Australian Wine Industry Technical Conference Planning Committee, the AWITC Program sub-committee and is Program Convenor for the 14th AWITC Workshop program. Con was one of the 15 successful candidates for the 2010 program intake for 'Future leaders – succession for the Australian wine sector'.

Dr Peter Dry is an Adjunct Associate Professor, University of Adelaide, a member of the Phylloxera and Grape Industry Board of SA and Associate Editor of the *Australian Journal of Grape and Wine Research* and the *Australian and New Zealand Wine Industry Journal*.

Creina Stockley is an Affiliate Senior Lecturer, School of Agriculture and Wine, The University of Adelaide and is the Coordinator of the Wine Science Course entitled *Grape Industry Practice, Policy and Communication*. She is a member of the National Drug and the Alcohol Research Centre's Young People and Alcohol Project Advisory Group, the National Alcohol Knowledgebase Expert Working Group, the Winemakers' Federation of Australia (WFA) Wine Industry Technical Advisory Committee, WFA Wine industry National Environment Committee and the WFA Wine and Social Responsibility Committee. She is also the DAFF nominated Australian delegate for the Organisation International de la Vigne et du Vin (OIV) Health and Safety Commission (IV), and is currently the President of the Food Safety Expert Group. She is also a member of the honorary editorial board of the *International Journal of Wine Research* (Dove Medical Press), and of the Scientific Committee for the 2010 International Wine and Health Conference to be held in Italy, as well as a charter member of the International Scientific Forum on Alcohol Research and a member of the Scientific Board of the [European] Wine Information Council. In addition, Creina is also a member if the 14th Australian Wine Industry Technical Conference Program Sub-Committee.

Vince O'Brien is an Adjunct lecturer at the University of Adelaide and member of the following committees: 14th Australian Wine Industry Technical Conference Planning Committee, Winery Engineering Association Conference Planning Committee, Nomacorc Advisory Committee and Wine Industry Suppliers Association Innovation Committee.

Leanne Craddock is a member of the IWAG (Inter Winery Analysis Group) committee.

Roxanne Portolesi is a member of the AusBiotech Committee (SA Branch).

Acknowledgements

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Photography by Jacqui Way Photography

Grape and wine composition

Defining and controlling important volatile compounds and their impact on wine aroma and flavour

Staff and students

Dr David Jeffery, Dr Elizabeth Waters, Dr Sally-Jean Bell, Dr Yoji Hayasaka, Dr Jason Geue, Dr Cory Black (since January 2010), Dr Paul Henschke, Dr Maurizio Ugliano, Dr Chris Curtin, Dimitra Capone, Tracey Siebert, Katryna van Leeuwen, Kevin Pardon, Mark Solomon, Natoiya Lloyd (since May 2010), Gayle Baldock, Mango Parker, Marcel Essling, Richard Gawel, Ellie King (PhD student, University of Adelaide), Radka Kolouchova, Sylvester Holt, Robyn Kievit and Gal Winter (PhD student, University of Western Sydney)

Collaborators

Adelaide Hills Vine Improvement Inc. (David Coleman); Curtin University of Technology (Dr Ayalsew Zerihun); Flinders University (Associate Professor Michael Perkins, Associate Professor Martin Johnston, Dr Peter Anderson); Lerida Estate (Jim Lumbers); Mt Majura Vineyard (Frank van de Loo); Orlando Wines (Hylton McLean, Nick Bruer, Brian Wyatt, Angus Davidson); Shaw and Smith Winery (Darryl Catlin); Casella Wines (Steve Warne, Frank Mallamace); The Yalumba Wine Company (Greg Edwards, Louisa Rose); University of Adelaide (Professor Dennis Taylor, Dr Mark Sefton, Dr Gordon Elsey, Dr Sue Bastian); University of Auckland (Associate Professor Paul Kilmartin, Gerard Logan)

An understanding of the relationship between wine composition and wine aroma and flavour is essential to be able to influence and optimise grape and wine quality. We target aromas and flavours responsible for important varietal and bottle-age characters, and characters associated with oak, wine microorganisms, and oxidation, as well as taints, 'off-flavours', 'reduced', and 'green' characters. Our objectives are to determine the chemical nature of hitherto unrecognised important volatile wine components; enhance our understanding of the relationship between wine composition and sensory properties; develop analytical methods for important wine components and their precursors; and determine the effect of viticultural and oenological techniques and wine storage conditions on the formation and fate of these compounds.

Characterising key compounds of the aroma and flavour in unique Australian wine styles remains a priority, with activity in a number of topical areas of research. On an on-going basis, lead compounds are being identified, and measurement capability is being developed for varietal and fermentative aromas which contribute to mint, spice, tropical and berry characters in Australian wines. We also aim to identify new compounds which impact on wine aroma. Methods for analysis of sulfur compounds and precursors are being investigated, including application of methods to determine the impact of a number of sulfur compounds on reductive characters or off-flavours in wine. The capacity to react quickly to assess taint and fault issues is continually being strengthened, with synthetic and analytical chemistry playing key roles in providing resolution of these unforeseen events.

Eucalyptol

Over a number of years, we have investigated grape and wine samples for the presence of eucalyptol, which contributes 'cooling', 'medicinal' and 'eucalyptus' characters to wines at low µg/L levels. We developed an analytical method; began investigations with industry samples; and undertook a survey of commercial wines, revealing that the character was virtually exclusive to red wines and was potentially influenced by Eucalyptus trees surrounding or within vineyards. Still, the origin of eucalyptol in wine was unclear, as it was reported that grape-derived terpenoids could act as precursors during winemaking.

We have recently completed a series of studies in order to address the origins of eucalyptol in Australian wines, which included vineyard, winery and laboratory experiments. We followed two separate red wine ferments with daily sampling, revealing continuous increases in eucalyptol concentrations until the ferments were pressed off skins. This indicated that eucalyptol was extracted from the skins (or material other than grapes, MOG) and was consistent with the association of eucalyptol with red wines only. Detailed studies in the vineyard involved determining eucalyptol concentrations in grape, leaf and stem samples obtained at different distances to a stand of Eucalyptus trees. Figure 1 shows the distribution of eucalyptol, with the majority found in the leaves followed by the skins. The Figure highlights the effect of proximity to Eucalyptus trees, where greater amounts of eucalyptol are found on grapes, leaves and stems grown closer to the trees. To confirm the effects of airborne transmission of eucalyptol from nearby Eucalyptus trees, polyethylene 'traps' were installed in the grapevine canopy in different orientations and at various distances from the trees. Polyethylene was found to be a good absorber of eucalyptol, and results from the analysis of the 'traps' confirmed the effect of distance observed for the grapevine samples. During this exercise, we noted that eucalypt leaves, buds and bark were lodged in the canopy in the rows closest to the trees. Naturally these tree-derived samples contained high levels of eucalyptol, orders of magnitude greater than determined for any of the grapevine samples. If a small portion of such tree material was included in a ferment it could conceivably contribute significantly to the final eucalyptol concentration of a wine; this should be a consideration when machine-harvesting rows close to Eucalyptus trees.

We also examined the postulate that grape terpenoids could lead to eucalyptol in wine, and

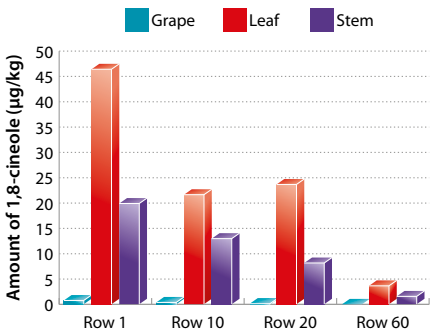


Figure 1. Concentration of eucalyptol measured in grape, leaf and stem samples at different distances to Eucalyptus trees (the distance to Eucalypt trees is increasing from row 1 to row 60)

assessed the stability of eucalyptol through hydrolytic and storage studies. When limonene and α-terpineol were spiked at unnaturally high concentrations into model wine and stored for 12 months at different pHs and temperatures, there was minimal conversion to eucalyptol of these potential precursors (i.e. sub-threshold eucalyptol formation). Eucalyptol was also stable over a 12 month period in model wine at different pHs and was barely affected by closure type during storage of a red wine for 12 months.

From our thorough investigations we have gained strong evidence that the majority of eucalyptol present in Australian red wine is derived from eucalyptus trees grown in close proximity to vineyards. This confirms the anecdotal evidence surrounding this wine aroma and flavour compound. We have determined that wine eucalyptol concentrations are affected by normal red wine fermentation conditions; the distance of grapevines to Eucalyptus trees; and potentially the level of MOG included in a ferment. Wine eucalyptol concentrations are relatively unaffected by the presence of two terpenoid precursors; the type of closure used; and storage conditions, at least up to 12 months, and probably beyond.

Varietal thiol precursor studies

Varietal thiols such as 3-mercaptohexan-1-ol (3-MH) are significant aroma compounds which impart desirable citrus and tropical notes to wine. Interestingly, these thiols are bound in grapes as odourless, non-volatile conjugates which release the free volatiles during fermentation. Currently, the known precursors to 3-MH are cysteinylhexan-1-ol (Cys-3-MH) and glutathionylhexan-1-ol (Glut-3-MH), which are conjugates involving the amino acid cysteine and the tripeptide glutathione, with each conjugate existing in two diastereomeric isomers. Due to the importance of the free thiols as impact odorants in wine, we aim to identify the factors that lead to the formation of the conjugates and whether we have any control over precursor formation and degradation during grape processing and winemaking. In addition, we strive to relate the structures and abundance of individual precursors in juice to the abundance of the free thiols in wine, and to wine flavour.

We carried out various analytical and fermentation studies to gain an understanding of the formation of precursors and the degradation during winemaking. Having previously synthesised a number of compounds required for this work, we developed and applied an HPLC-MS/MS method for the quantitation of the main precursors to 3-MH. After analysing a variety of commercial-scale white juices and wines, we have shown that the glutathione conjugate of 3-MH dominates over the cysteine conjugate, and that appreciable quantities of precursors remain in wines after fermentation. We identified that Glut-3-MH was up to 35 times higher than Cys-3-MH in a range of juices. It was also interesting, although not surprising, that the greatest amounts of these precursors were found in Sauvignon Blanc, which is typified by a tropical varietal character. The other varieties examined (Chardonnay, Riesling, Pinot Grigio) contained these precursors to a lesser extent, but in quantities capable of releasing measurable amounts of 3-MH into wine. Precursor trends for the wines were consistent with those observed for the juices, with Sauvignon Blanc once again containing the greatest amounts of precursors. The impact these residual precursors may have on the potential for thiol release in-mouth or in the bottle will be worth investigating in the future.

We have also shown the link between glutathione and cysteine conjugates and the free volatile 3-MH through lab-scale fermentation experiments. Fermentations conducted with a pure Glut-3-MH diastereomer and modified VIN13 yeast in model media showed for the first time that a glutathione conjugate could release the free thiol 3-MH, with the cysteine conjugate being formed in the process. Based on this study, we can infer that Glut-3-MH is a precursor to 3-MH found in wine, most likely via the cysteine conjugate as an intermediate, with a molar conversion yield of about 3% in our model system. Results for Cys-3-MH fermentations undertaken in the same manner showed an approximate molar conversion of 14%, highlighting that Cys-3-MH is probably more easily metabolised by yeast. In combination, these analytical and fermentation results help increase our understanding of the formation of tropical wine flavours. Along with other analytical methods being developed for free thiol analysis, we ultimately hope to optimise precursor formation and selective release and relate fruit composition and varietal characters to the corresponding grape and wine chemistry.

Unraveling yeast metabolism of varietal thiols

The varietal thiol 3-mercaptohexan-1-ol (3MH), which imparts tropical and citrus aromas, is released by yeast from aroma-less conjugates of cysteine and glutathione (Cys-3MH, GSH-3MH), as demonstrated in model studies reported elsewhere in this report. In order to modulate concentrations of free 3MH and its potent acetate ester 3-mercaptohexyl-acetate (3MHA), which contribute tropical and cat urine aromas to wine, we are unraveling the biochemical pathways responsible for their production by yeast. Current knowledge of 3MH release and conversion is summarised in Figure 2, where solid lines indicate aspects investigated directly for varietal thiol conjugates and broken lines indicate likely pathways extrapolated from studies of glutathione catabolism. In a recent study (Winter et al. Aust. J. Grape & Wine Res. *Accepted*), two key observations were made. First, yields of 3MH from GSH-3MH were lower than for Cys-3MH (confirming findings reported elsewhere in this report), yet the amount of 3MHA produced was similar. Therefore it appears that the type of precursor has some influence on esterification (Figure 3). Secondly, 3MH could not be released from Glut-3MH *in-vitro* using a known carbon-sulfur β-lyase enzyme, supporting the involvement of pathways indicated with broken lines in Figure 2.

In a collaborative project with Dr Peter Anderson (Flinders University) we have continued to investigate yeast genes that encode carbon-sulfur β-lyase enzymes. Previous studies, using strains with single gene deletions, suggested that several genes may be responsible for the release of varietal thiols. Until each gene has been investigated, the thiol-releasing capabilities of yeast strains under winemaking conditions will remain difficult to predict. By placing genes encoding two putative thiol-releasing enzymes (Str3p and Irc7p) under the control of a strong promoter (i.e. by ensuring that these enzymes are present in the yeast at all times and in higher than 'normal' concentrations) we have observed enhanced 3MH release during fermentation of Sauvignon Blanc.

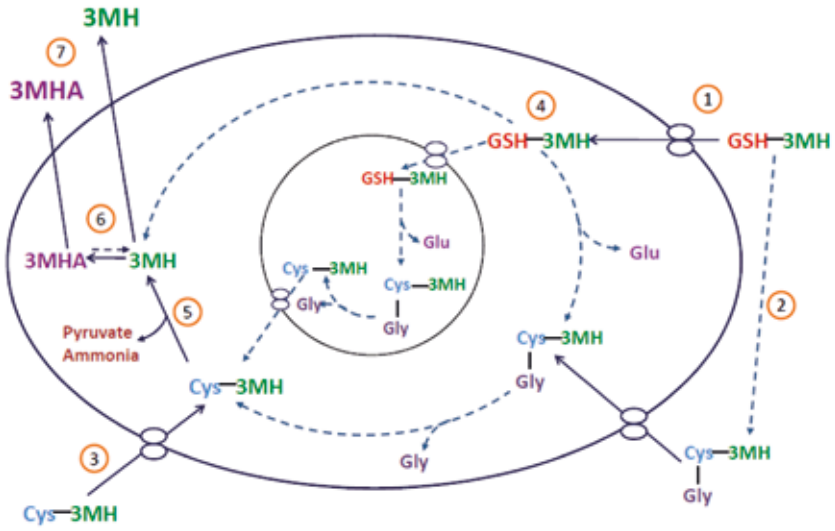


Figure 2. Schematic of 3MH precursor conversion pathways to 3MH and 3MHA. (1) Transport of GSH-3MH into the cell through the GSH transporter *OPT1*; (2) Cleavage of GSH-3MH by γ-aminopeptidases present in the grape juice to form a dipeptide precursor and transport of the precursor into the cell; (3) Transport of Cys-3MH through the general amino acid transporter *GAP1*); (4) Cellular metabolism of GSH-3MH. Inferred pathways include direct cleavage of GSH-3MH to produce 3MH and the tripeptide Glu-Ala-Gly, or multi step degradation of the precursor through either the cytoplasm or vacuole to single amino acids, which are cleaved to release 3MH from its resulting cysteine conjugate (5) Release of 3MH from Cys-3MH by yeast β-lyase enzymes (6) Acetylation of 3MH to form 3MHA and hydrolysis of 3MHA to 3MH (7) Release of 3MH and 3MHA into the wine by unknown mechanisms

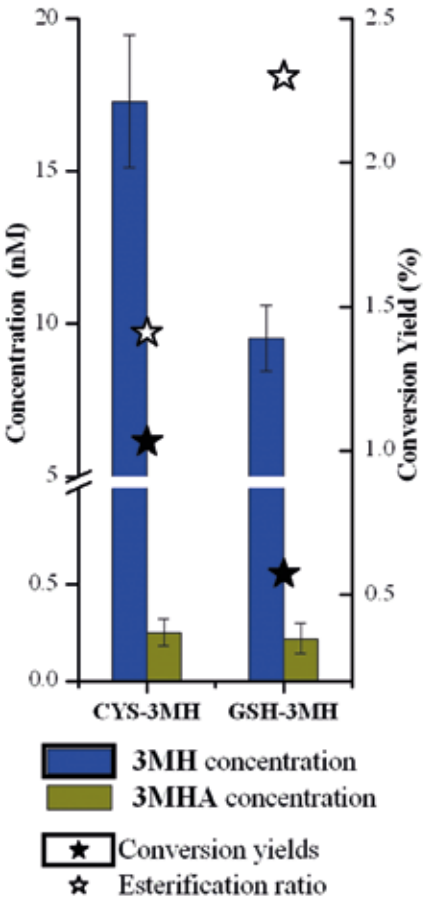


Figure 3. 3MH and 3MHA concentration at the end of alcoholic fermentations supplemented with either Cys-3MH or GSH-3MH. Molar conversion yields of 3MH+3MHA from Cys-3MH or GSH-3MH (black stars) and 3MH esterification ratios (white stars)

Award winning non-GM wine yeast

In addition to the above studies on yeast genetics, we continue work to develop non-GM, 'industry-ready', strains such as the low-H_2S strains commercialised by AB Mauri. One of these strains, 'Platinum', received an innovation award at Intervitis-Interfructa in Stuttgart, Germany earlier this year.

Longevity of varietal thiols in bottled Sauvignon Blanc wine

Studies conducted in collaboration with the AWRI Sensory team have clearly demonstrated that inoculation of must with different commercial *Saccharomyces* wine yeast strains leads to wines with different sensory properties (AWRI publications #1106, 1115) which impact on consumer preference (AWRI publication #1199). Nonetheless, it is a common assumption that any yeast-derived aroma and flavor differences evident in young wines soon after bottling, are likely to be short-lived.

Paul Henschke and Angus Forgan

Recent work has shown that yeast-derived sensory differences in Sauvignon Blanc wines are apparent after three years of bottle storage (AWRI publication #1209). Wines that contained the highest concentrations of varietal thiols (key aroma compounds for Sauvignon Blanc) while young, retained this differential after extended bottle storage. This study highlights the potential for yeast to influence white wine quality over a period relevant for consumption.

Fermentation-derived volatile sulfur compounds and reductive characters

The formation of volatile sulfur compounds may occur during various stages of wine production and storage. When present above their aroma thresholds, volatile sulfur compounds may contribute unpleasant 'off' or 'reduced' aromas to wine. Quantitative analysis is required to determine the influence of winemaking practises on formation of such volatile sulfur compounds. However, developing an appropriate analytical method is quite complicated, due to the volatile and reactive nature of these trace compounds. We previously developed a GC-SCD (SCD, sulfur chemoluminescence detection) method to quantify sulfur-containing aroma compounds in wine that have been associated with 'off-aromas' (Siebert et al. J. Agric. Food Chem. 2010 in press).

We have now completed a screening of bottled commercial wines using GC-SCD to further our understanding of sulfur compounds implicated in reductive sensory characters. Analysis was undertaken on 68 wines (28 white and 40 red of different vintages) that were described as 'reductive' during preliminary sensory evaluations. We were also involved with threshold studies for methanethiol (MeSH) and hydrogen sulfide (H_2S) to complement this work.

Virtually every white wine and the majority of red wines contained H_2S and MeSH, frequently above their aroma detection thresholds. Ethanethiol was scarcely detected and its sensory impact appeared to be insignificant in these wines, while dimethyl sulfide (DMS) was routinely found in both red and white wines above its aroma threshold. Depending on the wine matrix, DMS may enhance fruit characters at low levels (roughly 100 µg/L or less) or mask them with unpleasant 'vegetal' characters at higher levels. We identified that older wines (four to five years old) typically had the highest concentrations of DMS and we expect that the levels found in many wines from this sample set would contribute to undesirable sensory traits. Carbon disulfide was a ubiquitous sulfur compound in these wines and probably unimportant, although its impact on wine aroma is still not well understood. Diethyl sulfide and dimethyl disulfide were detected in a number of wines at levels which did not appear to have a negative sensory impact, while diethyl disulfide and ethyl thioacetate were not detected. Methyl thioacetate (MeSAc) was found at low levels in many red wines but only a few white wines, and was deemed not to be of concern in itself, although it can act as a source of the more potent MeSH over time.

Based on the study, the compounds most likely associated with reductive characters in these wines were H_2S, MeSH and DMS. The impact of carbon disulfide (CS_2) remains to be determined, while the concentrations of MeSAc encountered could lead to above threshold levels of MeSH with time, although this would depend on a number of factors such as dissolved oxygen and oxygen transmission rate of the closure, and wine pH. Complementing these findings, the method is currently being used across a number of research projects to build compositional databases on a wide variety of red and white wine samples. These databases will assist us to relate sensory properties to compositional data, and to enhance understanding of the formation and fate of these key sulfur compounds.

Managing fermentation nutrients and hydrogen sulfide accumulation in wine

This project aims to provide winemakers with better information on the role of fermentation nutrients, especially nitrogen, in wine flavour development. This information will assist winemakers to meet wine composition and sensory specifications. One of our objectives has been to investigate the role of nitrogen nutrients in modulating volatile sulfur compounds, principally hydrogen sulfide (H_2S). The balance of nutrients present in grape juices and musts is well known to critically affect yeast growth and fermentation activity, in the worst case leading to incomplete fermentation. Various nutrient supplements, such as diammonium phosphate (DAP) and proprietary yeast-derived products, can be used to ameliorate deficiencies, however, recent studies summarised in previous Annual Reports and publications (AWRI publications #875, 1001, 1022, 1093, 1121) have revealed that these supplements can markedly impact on wine flavour and style.

Off-flavours caused by volatile compounds derived from yeast metabolism during alcoholic fermentation are of major concern in the production of wine. H_2S is an important contributor to the so-called 'reductive' off-flavor present in some wines; its odour often being described as 'rotten egg' and 'putrefaction'. Various sources of H_2S have been described and include sulfur-containing agrochemicals, inorganic sulfur metabolism, organic sulfur metabolism, nutritional deficiency, metal cations and metals. Our recent studies concern H_2S that is largely formed by reduction of exogenous sulfate during the biosynthesis of the sulfur-containing amino acids. Based on the

observation that a negative correlation exists between naturally occurring nitrogen in the juice and total H_2S formed during fermentation, one commonly adopted strategy to limit formation of H_2S in wine fermentation is to provide adequate assimilable nitrogen. Diammonium phosphate is frequently added as a nitrogen supplement during fermentation. Nevertheless, some studies have reported poor correlation between H_2S and concentration of yeast assimilable nitrogen (YAN), suggesting the existence of more complex regulation mechanisms. Another common approach to the control of H_2S formation during fermentation is the use of commercial yeast strains that are low H_2S producers. However, the intrinsic ability of most commercial yeast strains to produce H_2S has predominantly been studied in model systems, often under conditions largely different from those commonly found in wine fermentations.

Due to its high volatility, most of the H_2S produced during fermentation is lost due to the purging action of CO_2. However, there is still a significant gap in understanding the relation between production of H_2S during fermentation and concentration of this metabolite in finished wines. Indeed, in many published studies it is implied that the total amount of H_2S formed during fermentation is important to wine quality due to its unpleasant aroma properties. It appears, however, that the accumulation of H_2S in finished wines is ultimately the quality parameter that needs to be managed.

In the previous year's Annual Report (2009) we summarised preliminary investigations into the relationship between H_2S formed during fermentation and residual H_2S that remained in the wine following fermentation. This work was conducted in a Shiraz must fermented with two yeast strains considered to be moderate to high producers of H_2S. This work suggested a poor relationship between fermentation H_2S and residual H_2S in finished wine (AWRI publication #1121). The present work was undertaken in order to systematically investigate this relationship. Fermentations were conducted in low nitrogen Chardonnay juice on a laboratory-scale with a serious of yeast strains previously characterised to show a wide range of capacities to produce H_2S. These low nitrogen juice fermentations were supplemented with DAP to produce moderate and high nitrogen contents, which is known to modulate H_2S production over a wide range.

The fermentations were monitored for H_2S production with detector tubes fitted to the outlet of each flask (AWRI publication #1208). The total amount of H_2S produced by each yeast during fermentation in juice containing low, moderate and high nitrogen is shown in Figure 4A. In general, the relative production of H_2S by each yeast strain was similar irrespective of juice nitrogen content. Furthermore, each yeast showed a similar non-linear response in H_2S production with

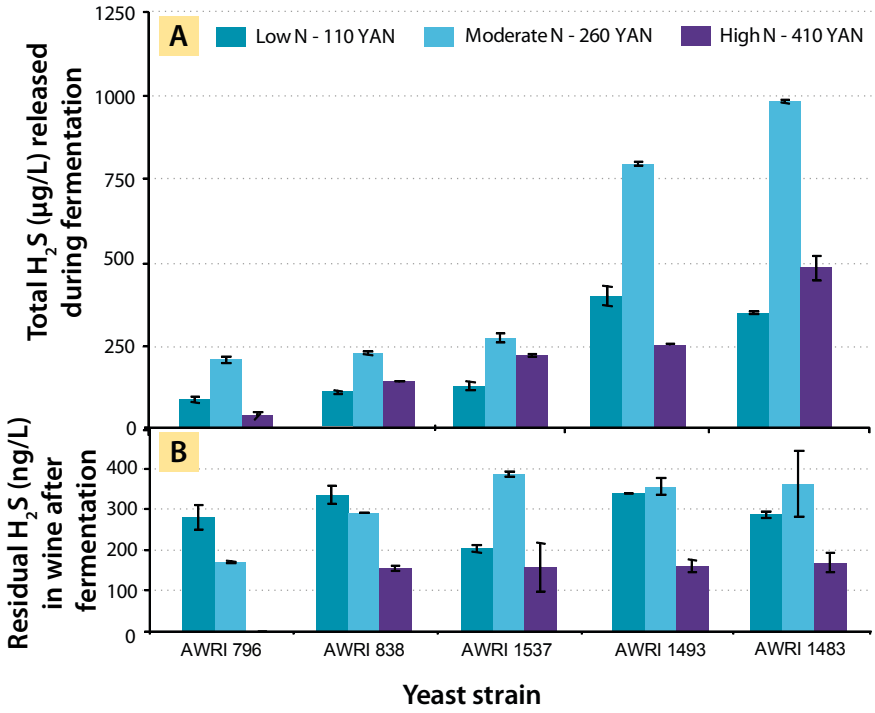


Figure 4. (A) Total amount of H_2S produced by each yeast during laboratory scale fermentation in Chardonnay juice containing low, moderate and high yeast assimilable nitrogen (YAN). (B) Residual H_2S present in each corresponding wine after cold-settling

juice nitrogen content. Several strains produced lowest totals of H_2S in low nitrogen juices whereas others produced lowest totals in high nitrogen juices. Overall, this experiment does not support the general view that moderate additions of DAP always minimise H_2S production. In order to better understand this apparent discrepancy, a review of the older literature on which this view has been founded suggests that low nitrogen juices are now considerably lower than several decades ago in part due to the move away from regular nitrogen applications in the vineyard so as to moderate vine vigour and excessive canopy development. After fermentation, the wines were cold-settled and the residual content of H_2S determined. The results are shown for each corresponding ferment in Figure 4B. It is immediately apparent that only a small proportion of the total H_2S produced during fermentation is retained by the wines (note the µg/L versus ng/L scales for Figure 4A and B, respectively). Furthermore, a comparison of Figure 4A and B shows that there is no apparent relationship between total H_2S produced during fermentation and residual H_2S in the corresponding wines. The large differences in H_2S produced by different yeast strains during fermentation was not reflected in wine H_2S content. On the contrary, there is a trend towards highest residual H_2S in wines made with low to moderate nitrogen contents and lowest residual H_2S in wines from high nitrogen ferments, largely irrespective of yeast strain.

This work was carried out on a laboratory-scale and so must be repeated in a winery setting in order to reveal whether scale-up effects exist. It is well known that volatiles are more readily lost from small volumes due to a higher surface area to volume ratio. Nevertheless, our results suggest that the extent of H_2S production during fermentation might not necessarily determine residual H_2S in wine after fermentation. Furthermore, these results suggest that juice factors such as nutrient content might be as important or perhaps more important than the choice of yeast used in the fermentation.

Some work has commenced into the role of wine matrix in the retention of H_2S in wine. So far, a study of a number of wine substances with the potential to interact with H_2S did not correlate with residual H_2S. Clearly, it is essential to understand the process(es) that govern(s) the retention of H_2S in wine so that this compound, which is known to contribute to the 'reductive' character can be better managed.

Effects of nitrogen application in the vineyard

The effects of nitrogen application on grape yeast assimilable nitrogen (YAN), wine composition and the sensory profile of Shiraz are being examined for a third and final season. The sensory evaluation of the 2009 wines and analysis of secondary metabolites in 2009 wines was undertaken and data are currently being analysed. The high salt levels in the irrigation water in the 2009 growing season resulted in elevated salt concentrations in petioles, grapes and wine so much so that the wines exceeded the Australian limit for salt in wine of 1 g/L of chloride expressed as sodium chloride. Pruning samples were taken to see whether chloride is being stored in the woody

tissue over dormancy. The results revealed that nitrogen supplementation in the vineyard had no effect on the sodium or chloride concentration in one-year old pruning wood. Just prior to budburst, soil samples were taken at three depths (0-20, 21-50, 51-75 cm) to see how far chloride had moved down the soil profile over the dormancy period. Electrical conductivity (EC), and the concentration of chloride, increased with depth. While the EC did not exceed 0.65 dS/m, chloride concentrations ranged from 100-300 mg/kg (0-20cm) to 600-650 mg/kg (51-75 cm).

The 2009/2010 season proved to be a challenging one: flowering and veraison occurred a week earlier than the previous seasons and during flowering the vines were subjected to a week-long heat wave. As a result, the grapes exhibited extremely uneven ripening, with symptoms of coulure and millerandage. Consequently, harvest had to be undertaken at five different dates in an attempt to ensure that each treatment was harvested at a similar maturity level. Wines were prepared from nitrogen-supplemented grapes harvested in the vineyard and by fermentation with and without equivalent DAP supplementation. All fermentations were successfully completed with the exception of two of the wines made from fruit from vines that received no nitrogen in the vineyard and were not supplemented with DAP in the winery; these wines had a very low YAN, less than 100 mg/L. Data analysis from comprehensive chemical analysis and sensory evaluation is currently being finalised; preliminary results have been compiled and a presentation entitled 'Manipulating nitrogen in the vineyard and the impact on secondary metabolites of red grapes and wine' was given at the GiESCO (Group of International Experts of Vitivinicultural Systems for Cooperation) conference in Davis, California (12-16 July 2009).

Phenolics and their contribution to wine composition and sensory properties

Staff and students

Dr James Kennedy, Dr Liz Waters, Dr Keren Bindon, Dr Yoji Hayasaka, Dr Helen Holt, Dr Jacqui McRae, Dr Martin Day (from 1 December 2009), Dr Bob Dambergs, Dr Leigh Francis, Belinda Bramley, Richard Gawel, Stella Kassara, Steven Van Sluyter, Mariola Kwiatkowski, Alex Schulkin (from 1 March 2010), Gemma West (WIC Winemaking Service), Simon Nordestgaard, (PhD student, The University of Adelaide)

Collaborators

Clover Hill (Karina Dambergs); Constellation Wines Australia (Chris Bevin); Croplands Ltd (Sean Mulvaney); Flextank International (Peter Steer); Frogmore Creek (Nick Glaetzer); Josef Chromy (Jeremy Dineen); Meadowbank Estate (Gerald Ellis); Moorilla (Conor van der Rees); Pernod Ricard Pacific (Inca Pearce, Leon Deans, Kate Lattey); Pooley Wines (Matt Pooley); SARDI (Dr Michael McCarthy, Amy Richards); Tamar Ridge Estate (Dr Andrew Pirie and Dr Richard Smart); Tasmanian Institute of Agricultural Research (Dr Dugald Close, Dr Kathy Evans); Tolpuddle Vineyard (Gerladine Colombo);The University of Adelaide (Dr Sue Bastian, Dr Chris Ford, Caroline Payne, Professor Brian O'Neill); University of Queensland (Dr Robert Falconer); University of Tasmania (PhD students Reuben Wells, Fiona Kerslake, Linda Donachie, James Gill, Anna Carew; Honours student, Ritchie Butler; Dr Tim Gale); Wine Industry Tasmania (Sheralee Davies); Jansz (Natalie Fryar); Winemaking Tasmania (Julian Alcorso).

This suite of projects has the objective of determining the function of phenolic compounds in grapes and wine. Of specific interest is identifying phenolic compounds that have importance with regard to wine colour, mouth-feel, and taste. We also aim to develop an understanding of grape and wine phenolic attributes related to consumer wine preference. With this in mind, the effective management of these components in the vineyard and winery to achieve a targeted wine composition, or style, is the desired outcome. Finally, the verification of potential and risks associated with novel practices and new technology are considered critical aspects to the success of the projects.

The relationship between red wine chemistry and quality

Stella Kassara has completed a project on the relationship between red wine chemistry and winemaker assessment of quality. The results from this study look very promising in terms of providing research direction; where total tannin and wine colour density were correlated with perceived wine quality judged by winemakers at Constellation Wines. Following Stella's collection of data, Daniel Cozzolino in the Industry Applications group provided statistical support for determining relationships between chemistry and assessment.

Interestingly and more specifically with regard to tannins, tannin chemistry associated with skin tannin *per se* (tannin size measured as mDP, and proportion of skin-derived prodelphinidins) were positively correlated with assessed quality. These results suggest that maximising the concentration of skin-derived phenolics is important for wine quality, and that maximising concentration and overall extractability of skin-derived phenolics are important parameters to investigate in future viticultural studies.

Plans are underway for the next phase of research which will focus on developing an assay for measuring the quantity and extractability of skin-derived colour and tannin in grape samples and relating this information to winemaker assessment of red wine quality. This development could potentially lead to an analytical approach for predicting wine allocation, in the vineyard, and would complement anthocyanin-based measurements.

Tannin extractability

Keren Bindon is nearing completion of a body of work on the effect of insoluble grape cell wall material on the selection of tannins (proanthocyanidins in Figure 5 during winemaking. From Keren's work, it is now evident that interactions between tannins and cell wall material play a role in the final concentration of tannins in wines.

Keren has shown that some selectivity for tannin by grape skin cell walls occurs: skin tannins of lower and intermediate molecular mass and also

(LtoR) Mark Solomon, Jacqui McRae, Jim Kennedy

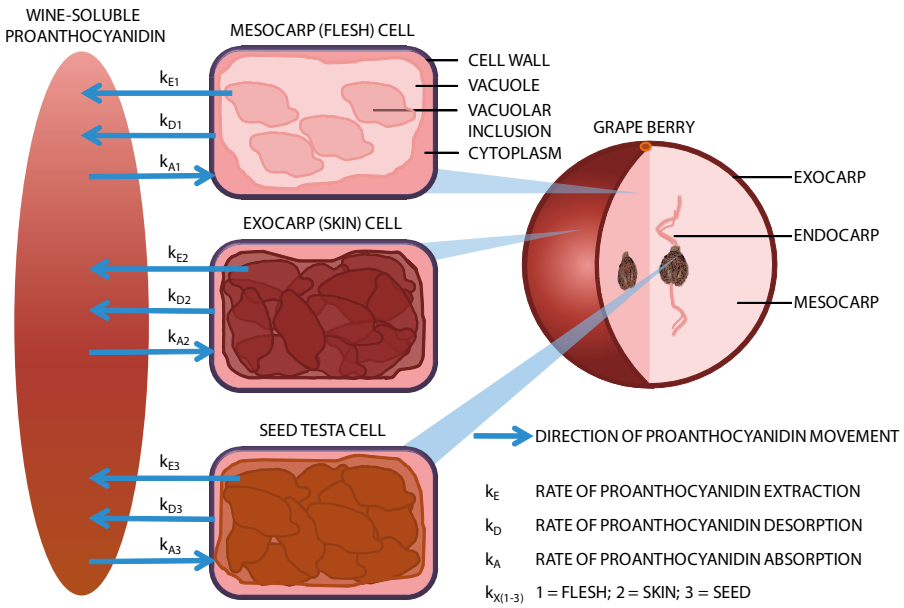


Figure 5. Representation for the various rate constants for tannin (proanthocyanidin) extraction from the different berry cell types, into wine. This representation is an oversimplification for mechanisms affecting tannin selection. For example, individual tannin molecules, varying in chain length and subunit composition, have individual rate constants for extraction, adsorption, and desorption

wine tannins of higher galloylation were selectively removed. The preliminary findings also show that skin cell wall material does not select for skin-derived tannin of higher molecular mass.

Keren has also conducted a vineyard maturity study for two seasons. The intent of this study is to understand the role of fruit maturity on the selectivity of tannin extraction and retention during wine production. Wines have been made from the grape samples at different ripeness levels. Each grape source has also been subjected to extraction experiments to determine maximum extractability of tannin from skin, seed and flesh in different solvent systems.

The findings to date have shown that changes in grape tannin structure, namely the degree of polymerisation and possibly the incorporation of either anthocyanin, or oxidation of the molecule, changes the way it interacts with cell wall material. Future experiments will explore the role of anthocyanin and/or tannin oxidation as possible agents which modify tannin interaction with cell walls during grape ripening.

It appears that changes in flesh cell wall structure during ripening have a limited effect on its affinity for tannin. On the other hand, the affinity of skin cell walls for tannin appears to increase during the ripening period. These results are currently being confirmed using tannins of different composition. Future work will aim to further characterise changes in cell wall composition and how these might influence or limit their binding with tannin.

These data suggest that extractability of tannin from grapes is influenced by grape maturity due to the impact of maturity on the tannins themselves in confirmation with changes in skin cell walls during maturation.

Astringency: tannin interaction with protein

Jacqui McRae has completed a series of experiments that were designed to explore how grape and wine tannins varied in their interaction with protein. Jacqui purified tannins from pre-veraison grapes (skin and seed), three-year old wines and 10-year old wines. Based on these results, investigations were initiated into the strength of the protein-tannin interaction. A major difference between the source of tannin, and its interaction with protein, was observed. Specifically, an observed difference was measured in the hydrophobic interaction of tannin with a synthetic protein composed of L-proline. Tannins isolated from older wines are more weakly associated with proteins. This research demonstrates the impact of changes in tannin structure upon wine ageing on the interaction with a peptide similar to salivary proteins. Tannins from older wines interacted more weakly with poly-(L-proline), suggesting that such tannins might be perceived as less astringent. These observations may, at least in part, explain why red wine 'softens' with age.

Further investigation was performed by Robert Falconer at the University of Queensland using isothermal titration calorimetry on pre-veraison and commercially ripe grape tannin as well as the selection of tannins from three-year old and 10-year old wines used previously. The findings of this study demonstrated that the impact of grape ripening and wine ageing on tannin structure directly reduced the strength of the interaction with poly-(l-proline) that was independent of tannin size. Further research is underway to explain the potential of ITC and related techniques for measuring and predicting tannin-related mouthfeel properties.

Viticultural and winemaking aspects of sparkling wine and Pinot Noir production

The Tasmanian node of the AWRI is housed within the Tasmanian Institute of Agricultural Research (TIAR), in the School of Agriculture at the University of Tasmania and is in the second year of operation. The Tasmanian node performs a research function as part of an AusIndustry-funded industry collaborative innovation program and but also acts as a conduit for general AWRI research and extension activities. Since the original formation of the Tasmanian node, a dedicated laboratory has been developed at TIAR at Sandy Bay. This has become the 'Wine laboratory', acting as a central hub for grape and wine projects in Tasmania, and is linking in closely with other research within The University of Tasmania. For example, a new research project that complements the analytical chemistry capabilities at the AWRI has been established in collaboration with The Australian Centre for Research on Separation Science (ACROSS) at the University of Tasmania.

The AusIndustry-funded collaborative research program has a practical focus on viticultural and winemaking aspects of sparkling wine and Pinot Noir production; the foremost wine styles produced in the cool climate of Tasmania. The projects aim to generate practical outcomes and work is performed in close collaboration with industry partners.

On the viticultural side, projects revolve around the influence of vineyard management techniques on grape quality, with wines made from the vineyard trials following a standard protocol. The treatments include classical viticultural methods used in cool climate viticulture such as pruning methods, canopy management, leaf removal, shoot thinning and crop thinning. To date, data indicate that in cool climates seasonal variation has the strongest influence and vineyards must be managed according to the season. Data analysis for these trials has strongly benefitted from the multivariate data analysis skills brought from the AWRI. Similarly, spectroscopy methods from the AWRI have been used to analyse samples: the AWRI has purchased a mid-infrared spectrophotometer for the Wine laboratory at TIAR in Sandy Bay, and a near infrared instrument in the Central Science Laboratory in the University of Tasmania has also been used for grape and wine analysis.

The second major group of projects involve adoption of winemaking methods to vary the final wine composition and sensory attributes. Pinot Noir has unusual tannin and anthocyanin

profiles that require specific vinification methods. Through small-lot winemaking trials, we have demonstrated the impact of some important control strategies with regard to tannin and pigment extraction and stabilisation in Pinot Noir wine. Winemaking trials are also part of the sparkling wine projects, with focus on the tirage and maturation stages as critical steps in the efficient production of premium sparkling wines.

Influences on white wine mouth-feel perception

Wine polysaccharides are thought to contribute positively to white wine texture. We have undertaken several studies this year to investigate this further. The first step has been to isolate sufficient quantities of polysaccharides in a food grade manner in order to be able to add the fractions back to wine and taste them. This was not a trivial task, because most methods for purifying polysaccharides involve the use of solvents and media that are not food safe. We exploited the potential of multi-layer counter-current chromatography for this purpose and were able to obtain moderate but reasonable quantities of polysaccharides from wines. This allowed us to study the aroma and taste impact of polysaccharides in wines over the low to moderate range in which they exist in wine.

Our first sensory studies suggested that the addition of polysaccharide resulted in a reduction in the perceived hotness of a higher alcohol Riesling. Further sensory studies using different base wines were undertaken to allow generalisation of our conclusions concerning the role of polysaccharides in palate hotness, viscosity and the phenolic taste. A polysaccharide extract from two commercial Chardonnay wines (one oaked and one unoaked) were extracted and purified before being added back to the same wine at two different alcohol levels. There was little evidence of any effect of polysaccharide addition on hotness and viscosity of the unoaked Chardonnay, but there was some evidence that polysaccharide addition reduced the perceived hotness of the oaked Chardonnay.

A second sensory trial was conducted to explore the effect of polysaccharides on the bitterness and astringency of a Riesling wine that had previously been deemed to be high in 'phenolic taste'. Polysaccharides taken from a commercial Riesling and a commercial Chardonnay wine were added back to Riesling wines made with 50% and 100% heavy pressings. No consistent effect was observed of polysaccharide addition on the bitterness or astringency of these phenolic wines.

From these studies, it appears that the effect of wine polysaccharide addition to white wines on their sensory properties is generally weak when the augmentation in polysaccharide concentration is in the low to moderate range. Sensory trials with higher levels of polysaccharides need to be conducted before we can conclude that wine polysaccharides have little impact on the sensory properties of wines across the full concentration range they are found in wine.

Yoji Hayasaka and Jeremy Hack

'Phenolic' taste in white wines

The ultimate aim of this project is to gain a greater understanding of how post-harvesting procedures and wine processing affect 'phenolic taste' in white wines and hence wine quality. We consider the best approach for this project is to focus on identifying the compounds responsible for 'phenolic' taste. Once we have the target compounds, we will be able to then more easily and efficiently generate data on specific processing methods that change the levels of these specific compounds of interest.

The first step in this strategy has been to generate an appropriate sample set of white wines for the project that differ primarily in 'phenolic' taste and not other attributes. Experimental winemaking was undertaken by Gemma West and Martin Day in order to generate these wines. These experimental wines differed in phenolic concentration, but not in most other wine compositional parameters. This was important because residual sugar, titratable acidity and pH are known to effect the perception of phenolic taste and it is possible that other common wine compositional parameters may impact indirectly also on the perception of phenolic taste. It was not trivial to achieve this consistently on a small-scale but was essential for the project. These wines will allow us to focus on the contribution of phenolic compounds to phenolic tastes, such as astringency and bitterness, without the confounding presence of different concentrations of other wine compounds like acids, which are perceived as astringent, or ethanol which is bitter.

The second step was to fractionate these wines and use sensory analysis of the fractions to guide further fractionation until we had identified the compounds responsible for 'phenolic' taste: a senso-metabolomic approach. As a prerequisite to achieving this target, we required improved analytical separation techniques to characterise the phenolic fractions and identify individual compounds. Steve Van Sluyter and Martin Day have developed new HPLC techniques capable of resolving many more phenolic compounds than existing methods. Following the screening of suitable HPLC columns with enhanced specificity for phenyl-containing compounds, an HPLC method (two Phenyl columns placed in serial) was developed to resolve >80 phenolic compounds. Optimisation of gradient conditions has been carried out and the method migrated to use a more stable binary pump. This method should place us in an excellent position for compositional analysis. The second requirement for a senso-metabolomic approach was to develop methods to produce fractions from wines in sufficient quantities for sensory analysis, and in a food grade manner. Steve Van Sluyter developed a food grade chromatography method that isolates and separates phenolics into four distinct fractions. Steve has also developed a low pressure chromatography method to isolate total phenolics from wine in sufficient quantities for sensory analysis.

The effects of pH and ethanol on 'phenolic taste' needed to be studied before individual phenolic fractions were assessed. A fraction of total phenolics from one of the 2009 experimental wines was added back to a commercial base wine at two pH and two ethanol concentrations. Sensory analysis led by Richard Gawel showed a significant effect of phenolic extract addition on perceived

astringency, particularly when the wine was at the higher pH level. No consistent effects of phenolic extract addition on bitterness or acidity were observed. However, perceived hotness increased significantly following the addition of the phenolic extract. This effect, while being robust across all alcohol and pH levels, was particularly pronounced when the base wine was at the lower alcohol level. A further sensory trial was undertaken to confirm these observed textural effects. Total phenolics were extracted from a further three additional phenolic wines and added back into two neutral base wines at two alcohol levels. The addition of phenolics increased the bitterness, astringency and viscosity of the base wines. The source of the phenolics also differentially affected these attributes. While the effect of phenolic addition on hotness was not statistically significant, the mean perceived hotness increased over the control wines when any of the three different phenolic pools were added. There was also some evidence that ethanol-induced hotness was a confounding factor in this case.

These results clearly demonstrate that white wine texture is, in part, dependent on phenolic composition. The creation, characterisation and formal sensory evaluation of refined phenolic fractions will help us to better understand their role.

Identification of glycosides as key contributors to smoke taint

Staff

Dr Yoji Hayasaka, Gayle Baldock, Mango Parker, Dr Cory Black, Dr David Jeffery, Kevin Pardon

Collaborators

The AWRI Industry Development and Support and Sensory teams, and Commercial Services; The University of Adelaide (Dr Kerry Wilkinson, Dr Renata Ristic, Kerry Dungey); DPI Victoria (Dr Mark Downey) and Wine Sector partners.

In 2003, undesirable sensory effects of wine made from smoke-affected grapes were first noticed as a potential problem by Australian wine producers, after a large number of vineyards were exposed to smoke from a series of bushfires. Since then, increasing occurrences of bushfires in the vicinity of grape-growing regions in Australia have led grape and wine researchers and practitioners to investigate the effect of smoke on grapevine physiology, grape and wine composition, and sensory characteristics. The challenges are to measure smoke exposure in grapes prior to winemaking and to develop winemaking practices to minimise or reduce undesirable smoke-related characters of wine made from smoke-affected grapes.

The focus of our research is i) development of diagnostic assays to identify smoke-affected grapes and predict smoke taint in wine, and ii) to investigate smoke-derived compounds responsible for smoke-related aroma and flavour.

Synthesis of reference glycosides for smoke-taint diagnostics

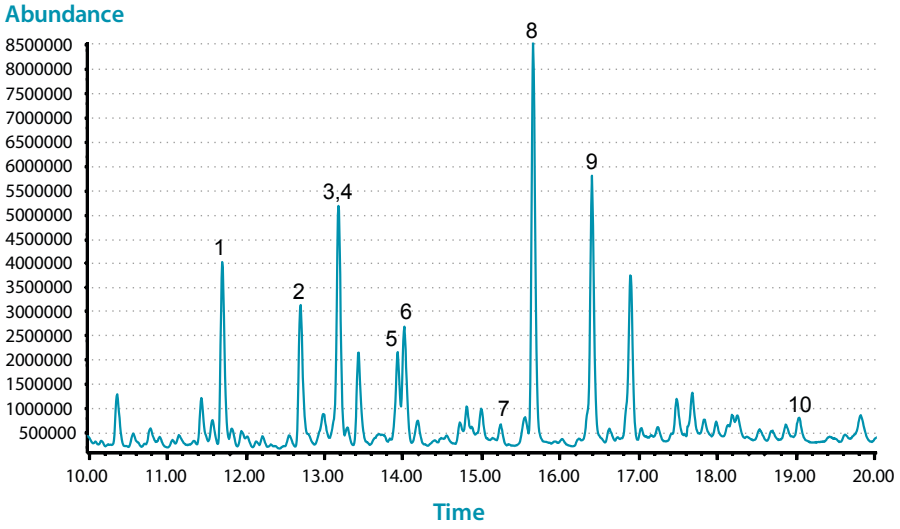
Understanding smoke-taint phenomena continues to be a focal point for us. Previously, isotope tracer studies have shown that after guaiacol, a known smoke-taint compound, was applied to grape vine leaves or berries during ripening, there was extensive modification of the compound by the grapevine (AWRI publication #1179). This resulted in the formation of various glycosides of guaiacol, which are water soluble and non-volatile, but act as sources of guaiacol during fermentation and storage. It is important, therefore, to not only be aware of the presence of the guaiacol derived from bushfire smoke, but also to appreciate the significant pool of guaiacol conjugates that may release guaiacol.

Further pioneering analytical work by researchers at the AWRI identified additional smoke-derived phenols, which could logically undergo the same fate observed for guaiacol; that is, conjugation to sugars within the plant and release of volatiles during winemaking and storage. To prove this hypothesis, we undertook the synthesis of a variety of phenol glycosides in order to assist the development of diagnostic assays and to provide authentic material for sensory testing. We began with the synthesis of d_3-syringol, which is now available as an internal standard for quantitative GC-MS work, and developed methodology for the formation of syringol glucosylglucoside and its labelled analogue. This particularly challenging glycoside synthesis provided us with substantial quantities of pure, well-characterised syringol monoglucoside and its d_3-analogue as intermediates, and enough of the pure glucosylglucoside to undertake method development and validation for analysis of these conjugates in grape juice and wine. We also prepared a number of cresol glucosides in highly pure form and are in the process of synthesising glucosides of other smoke-derived phenols. The natural presence of a number of these glycosides in smoke-affected juices and wines was confirmed with the use of the synthetic compounds. Future work will focus on sensory aspects and rates of hydrolysis of these glycosides in wine, to develop knowledge about the concentrations which may be tolerated and the length of time involved in release of undesirable levels of volatile phenols, particularly during storage.

Development of diagnostic assays to identify smoke-affected grapes and predict smoke taint in wine

Currently, guaiacol and 4-methylguaiacol are being been used as markers to assess the impact of smoke on grapes and wine because their concentrations in wine were reported to be strongly correlated with the intensity of the smoke effect (2003 AWRI annual report). However, the experience from the 2009 Victorian bushfires indicated that approximately 78% of grape samples (from more than 700 samples) submitted for free guaiacol analysis had less than the detection limit (1 µg/kg); more than 95% of suspect samples were found below 5 µg/kg. Despite the presence of only insignificant concentrations of guaiacol, the potential of these grapes to produce smoke-affected wine could not be ruled out entirely and we concluded that additional diagnostic assays to assess the impact of smoke on grapes and wine were needed.

In some instances, winemakers have observed that the smoke-related characters present in juice or must have increased after fermentation and continued intensifying in the wine over time, even after bottling. This anecdotal observation was experimentally confirmed in model experiments, where grapes and vines were exposed to



1: guaiacol, 2: 4-methylguaiacol, 3: o-cresol, 4: phenol, 5: p-cresol, 6: m-cresol, 7: vinylguaiacol, 8: syringol, 9: 4-methylsyringol, 10: vinylsyringol

Figure 6. GC-MS analysis of smoke VOCs from a prescribed burn-off

smoke from smoke generators (Kennison et al. 2008). We reported last year that seven different glycosides of guaiacol in grape berries and leaves were formed after direct contact with guaiacol solutions (AWRI publication #1179). The isotope tracer study also indicated there was minimal translocation of guaiacol glycosides between grapevine leaves and berries; the glycosides were present as low-level natural compounds in control leaves and berries; and the glycosides were present in significantly elevated amounts in leaves and berries following exposure of grapevines to smoke derived from actual bushfires. These glycosides are considered to be precursors which can release free guaiacol in wine.

Notably, smoke from bushfires contains a variety of volatile phenols other than guaiacol which have not been considered previously as contaminants in smoke-affected grape and wine. To investigate the profile of major smoke-derived volatile organic compounds (VOCs), smoke generated by a prescribed burn-off was analysed by GC-MS. In addition to guaiacol and methylguaiacol, a number of volatile phenols including syringol, methylsyringol, *o*-, *p*- and *m*-cresol, and phenol, were found to be major components of VOCs from smoke (Figure 6). Vinylguaiacol and vinylsyringol were also present as minor components. This demonstrated that grapevines can become severely exposed to a number of volatile phenols from bushfire events, as seen for guaiacol. Some of these volatile phenols also have distinctive smoke-related sensory characters which may contribute to the overall smoke-effect on grapes and wine.

Following on from what we had learnt about the formation of guaiacol glycosides, the glycosylation of these volatile phenols in grapes was investigated with the aid of various mass spectrometric techniques. As a result, a broad range of glycosides from all smoke-related volatile phenols was identified in both grapes and wine. In summary, as a consequence of grapevine exposure to smoke, a wide variety of volatile phenols are taken up by grapes and subsequently metabolised to various glycosides, in a similar fashion to guaiacol. Most volatile phenolic glycosides were found to be present in smoke-affected grapes and wines at significantly greater concentrations compared to those in non-smoked control grapes and wines.

Detailed HPLC-MS/MS analysis of phenolic glycosides in smoke-affected Cabernet Sauvignon grapes and wine made from these grapes showed that the profiles of the glycosides in the smoke-affected grape and corresponding wine samples were similar (Figure 7). However, the concentration of the total glycosides (sum of all glycosides measured) decreased from around 21 mg/kg (ppm) in the grapes to 14 mg/L (ppm) in the wine. Accordingly, the combined extraction and recovery rate from grape to wine was calculated to be 67%. Since a loss of glycosides resulting from chemical and enzymatic hydrolysis during fermentation could also have contributed to a reduction in concentration of glycosides in the wines, the overall extraction was likely even higher. This is to be expected as glycosides are usually highly water-soluble and can be readily extracted into musts and ferments. .

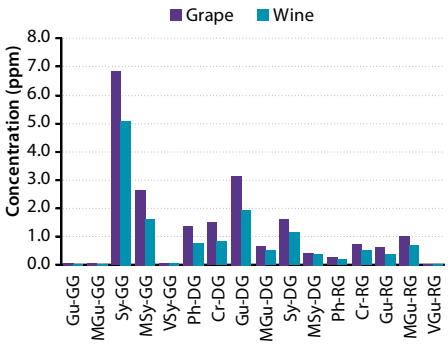


Figure 7. HPLC-MS quantitation of glycosides of volatile phenols in smoke-affected Cabernet Sauvignon grapes and wine made from these smoke-affected grapes. Ph: phenol, Cr: cresol, Gu: guaiacol, MGu: methylguaiacol, VGu: vinylguaiacol, Sy: syringol, MSy: methylsyringol, VSy: vinylsyringol

The release of volatile phenols from the glycosides was demonstrated by subjecting smoke-affected grapes (Chardonnay and Cabernet Sauvignon), and their corresponding wines, to harsh acid hydrolysis conditions (pH1, 100°C for 1 hour). After hydrolysis, approximately 50% of the total glycosides in the grape and 92% in wine samples of both varieties disappeared, respectively. This was accompanied by a concomitant increase in the total volatile phenols in the hydrolysates.

In summary, we continue to explore various volatile phenols and their glycosides as markers for smoke exposure by grapes based on the following assumptions: i) following exposure to smoke, the amount of volatile phenols taken up by grapes, and the concentration of their glycosides produced and accumulated in grapes, is correlated with the intensity and duration of smoke exposure; ii) since these glycosides can easily be extracted into wine, the quantification of glycosides in grapes and wine can be used for estimating smoke exposure and for predicting the potential of grapes to produce smoke-affected wine, and iii) the glycosides can act as a pool of precursors that may release and increase volatile phenols during alcoholic and malolactic fermentations, ageing, and storage.

For the above reasons, various analytical approaches to effectively quantify phenolic glycosides are currently being assessed as risk management and decision support tools; this investigation is in progress.

Investigation of smoke-derived compounds responsible for smoke-effect aroma and flavour

During early investigations into smoke-effect (2003 AWRI annual report), guaiacol was found to impart a distinct smoky character to smoke affected wines, but it was noted that guaiacol and 4-methylguaiacol were not likely to be solely responsible for the undesirable sensory effects. The addition of guaiacol to a base wine, at concentrations found in smoke affected wines, did not produce the same 'excessively drying' palate, or 'lingering retronasal ash character' that was noticed in smoke-affected wines. Therefore, we sought to identify additional key impact aroma and/or flavour compounds.

In order to investigate relationships between composition and sensory attributes, a comprehensive sensory study, using quantitative descriptive analysis, was performed on a set of 20 wines, including three control wines, four research wines made from smoke-affected 2009 grapes, and 13 smoke-affected 2009 wines sourced from wineries. The trained panel found significant differences in the

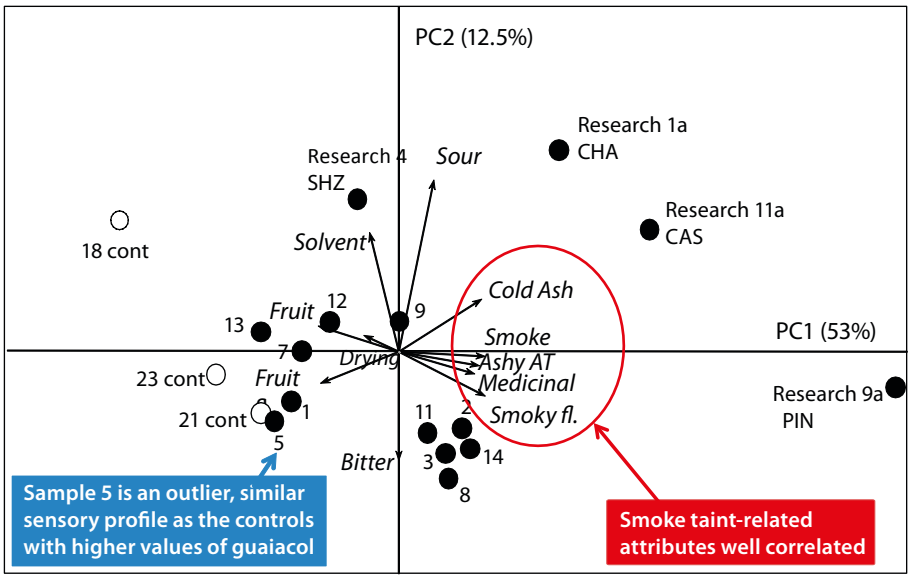


Figure 8. Sensory Principal Component Analysis (PCA) plot, PCA1 vs PCA2

aroma terms 'overall fruit, cold ash, smoke, medicinal, and solvent' and palate terms 'overall fruit flavour, smoky flavour, sour, bitter, ashy aftertaste, and drying'. Notably, the smoke taint related sensory attributes were all closely correlated.

As can be seen in Figure 8, control wines (open circles) had not been affected by bushfire smoke. Wines 1a, 9a and 11a were made at the AWRI from frozen grapes affected by the 2009 bushfires. Wines 4 to 16 were smoke-affected wines from the same fire event. Wine 1a is a Chardonnay made with skin contact.

When relationships between the sensory attributes and chemical composition of the wines were investigated using PCA and Partial Least Squares (PLS) techniques, this revealed a strong relationship between guaiacol and the cresols, and the smoke related sensory attributes, in particular the 'smoky flavor' and 'ashy aftertaste'. To investigate the sensory importance of these phenolic compounds, aroma threshold testing (best estimate threshold) was undertaken, in a neutral red wine low in guaiacol and *o*-, *m*-, and *p*-cresol. In addition, the taste threshold for guaiacol was also recorded, and was found to be very similar to the aroma threshold (Figure 9).

To further verify the sensory impact of guaiacol and the volatile phenols, a base red wine was spiked with levels of these compounds found in a smoke-affected wine, in a reconstitution experiment, and compared to the unspiked base wine, and the actual smoke-affected wine. When the spiked wine was tasted in an informal bench tasting, the panel described this wine as similar to the actual smoke-affected wine, but lacking intensity in the lingering ashy flavour or aftertaste; this pointed to the involvement of additional compounds.

As described above, a large number of glycosides of volatile phenols has been detected in smoke-affected wines in significant concentrations, up to 14 mg/L or approximately 100x higher concentration than the free phenols. These glycosides can be hydrolysed during vinification and ageing, releasing aroma-active free volatiles. We decided to investigate whether the glycosides could impart any direct sensory attributes themselves, such as the drying palate character, or smoky taste or flavour. The AWRI flavour chemistry team synthesised pure reference materials for this project, including guaiacol glucoside, *m*-cresol glucoside, and syringol glucoside, and these were used in a formal sensory study. The compounds were assessed by a sensory panel in model wine (10% food grade ethanol in saturated potassium hydrogen tartrate solution) at 0.5 mg/L. The concentration of the free volatiles was confirmed to be below 1 µg/L. The panel (N=30) rated 'smoky' and 'medicinal' aroma, and 'smoky/ashy' and 'medicinal' flavour, in duplicate, with a forced rest of two minutes between samples (Figure 10).

In this sensory experiment, the presence of guaiacol and *m*-cresol glucosides caused significant smoky/ashy flavour compared to the control, despite imparting no significant difference in the aroma compared to model wine. There was no significant effect for the syringol glucoside. While the medicinal flavour was not significant overall, there were nine sensitive panel members who could detect a significant medicinal flavour due to the *m*-cresol glucoside. Guaiacol analysis (by GC-MS) of expectorated samples confirmed that free volatiles had been released. This implies that the glycosidic bonds are being hydrolysed in the mouth, perhaps by salivary enzymes or microbes, releasing free volatiles that are perceptible retronasally. Further work has been initiated to investigate the flavour activities of the full range of diverse glycosides present in smoke-affected wines, and to assess the contribution of glycosides, relative to free volatiles, to the smoky and medicinal flavours.

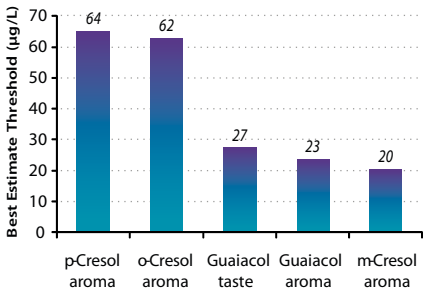


Figure 9. Sensory detection threshold values of four smoke-related compounds in red wine

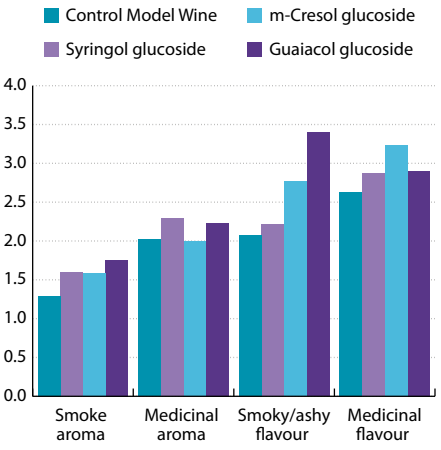


Figure 10. Aromas and flavours associated with glucosides of smoke-related phenols (samples with different letters are significantly different, p=0.01).

Histamine content in Australian red and white wine

Staff

Dr Eveline Bartowsky, Jane McCarthy

Lactic acid bacteria (LAB) play an important role in wine production and are responsible for secondary, malolactic fermentation (MLF). *Oenococcus oeni* is the principal LAB involved in MLF. Other *Lactobacillus* and *Pediococcus* species can also drive MLF, however, they have a tendency to produce undesirable aroma and flavour compounds, and some have the potential to impact negatively on health. One undesirable group of compounds produced by LAB is the biogenic amines.

Histamine is the main biogenic amine found in wine. Biogenic amines are essential for many physiological functions, however, when adsorbed at elevated concentrations in the diet they can induce, in some individuals, headaches, gastrointestinal and respiratory distress.

A survey of 100 red and whites wines sourced from 2003-2009 vintages was compared with a survey undertaken in 1991 of wines from vintages 1982-1990; wines were from all major Australian winemaking regions and from small-, medium- and large-scale wine producers. There were no great changes in the mean histamine concentration in the five most representative grape varieties (Chardonnay, Cabernet Sauvignon, Merlot, Pinot Noir and Shiraz) across the 27 years (Figure 11). Small increases were observed in Chardonnay (0.30 to 0.59 mg/L) and Cabernet Sauvignon (1.31 to 1.48 mg/L), minimal change in Shiraz (1.48 to 1.57 mg/L) and a decrease in Merlot (2.06 to 0.97 mg/L).

Pinot Noir wines had the highest histamine concentration of all wines from both survey periods. One Pinot Noir from the 2003-2009 survey had a significantly higher histamine concentration (14.54 mg/L) than all other wines. When this sample is excluded from the data set, the mean histamine concentration between the 1982-1990 and 2003-2009 surveys had little variation: 3.82 mg/L (1982-1990 data set) compared to 3.77 mg/L (2003-2009 data set). Interestingly, the Pinot Noir wine with the very high histamine content also showed several spoilage characteristics: the acetic acid concentration was elevated compared to the other Pinot Noir wines (1.1 g/L compared to 0.48-0.88 in the other six wines), and the total sulfur dioxide concentration was reduced from the average bottled red wine (42 mg/L compared to expected range of 70-90 mg/L).

Jenny Bellon and Jane McCarthy

This study has highlighted that there has not been any major changes in Australian wine histamine content in red and white wines over the last 25 years. Histamine concentrations in the red and white wines were well below the recommended upper limit of 10 mg/L. Nonetheless, winemakers should ensure that good winemaking practices are followed to minimise growth of spoilage LAB in wine and to minimise any potential risk of elevated histamine concentrations in wine.

This project was supported jointly by a grant from the South Australian Government and the Grape and Wine Research and Development Corporation. The 1982-1990 histamine survey data were provided by Creina Stockley.

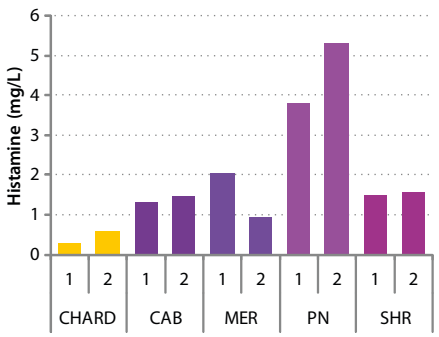


Figure 11. Comparison of mean histamine concentration in red and white Australian wines across a 27-year period. CHARD – Chardonnay, CAB-Cabernet Sauvignon, MER – Merlot, PN – Pinot Noir, SHR – Shiraz. 1 – 1982-1990, 2 – 2003-2009 vintage sampling periods

Grape and wine production

Improving microbial performance, wine diversity and wine quality

Staff and students

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Visiting scientists and students

Etjen Bizaj (PhD student, University of Ljubljana, Slovenia), Linda Donachie (University of Tasmania), Sara Landolfo (PhD student, Università Politecnica delle Marche, Ancona, Italy), Tommaso Liccioli (PhD student, University of Adelaide), Rocio Gomez Pastor (PhD student, Institute of Agrochemistry and Food Technology, Valencia, Spain), Nick Warnock (PhD student, Flinders University)

Collaborators

454 Life Sciences, A Roche Company (Dr Michael Egholm), AB Mauri, Australia (Dr Anthony Heinrich), Australian Genome Research Facility (Professor Sue Forrest, Dr Annette McGrath), Australian Proteome Analysis Facility (Professor Mark Baker, Dr Alamgir Khan), Bioplatforms Australia (Andrew Gilbert), Brock University, Canada (Professor Debra Inglis), Flinders University (Dr Peter Anderson), IASMA, Italy (Dr Giuseppe Versini), Laffort Australia (Dr Paul Boyer, Dr Tertius van der Westhuizen), Lallemand (Dr Ann Julien-Ortiz, Dr Sibylle Krieger-Weber, Dr Andrew Markides), Melbourne University (Professor Tony Bacic, Dr Ute Roessner), Murdoch University (Professor Matthew Bellgard), Stanford University, USA (Dr Barbara Dunn, Associate Professor Gavin Sherlock, Professor Michael Snyder), Universitat Rovira i Virgili (Professor Albert Mas), The University of Adelaide (Professor David Adelson, Dr Paul Grbin, Dr Vladimir Jiranek), University of Central Queensland (Professor Grant Stanley), University of New South Wales (Prof Marc Wilkins, Simone Li), University of Queensland (Professor Lars Keld-Nielsen, Dr Jens Kroemer), University of South Australia (Dr Miguel de Barros Lopes), University of Toronto, Canada (Professor Charles Boone), University of Western Sydney (Dr Vince Higgins), The Yalumba Wine Company (Louisa Rose, Simon Dillon)

The focus of Bioscience research at the AWRI is the improvement of microbial performance in wine fermentations, wine diversity and wine quality. Research in this broad arena encompasses physiology, genetics, molecular biology, biochemistry and systems biology of wine yeast and bacteria. The aims include: identifying and generating novel yeasts with improved winemaking and sensory-imparting properties; optimising fermentation outcomes by developing improved yeast nutrient supplementation regimes; improving robustness of wine yeasts and MLF bacteria; utilising MLF to enhance wine quality; and developing 'low-alcohol' yeasts. The following is an overview of some of the activities of the Biosciences team.

Strategies for reducing alcohol levels in wine

For reasons associated with public health policy, economics and product quality, there is a desire in the wine sector for the development of technologies that facilitate the production of wines with a lower alcohol content. The use of wine yeasts that produce less alcohol than those currently available to winemakers would be one way of achieving this. Therefore, we are trying to generate novel strains of wine yeast that metabolise sugar in such a way that substantially less ethanol is produced while maintaining high wine quality. We are applying both non-genetically modified (non-GM) and genetically modified (GM) approaches; the latter approach is being used for research purposes only to better inform us about what might be achievable.

We are using adaptive evolution strategies as a non-GM approach to generate a yeast that produces less ethanol than the currently available wine strains. One of the products of this work, the new yeast strain AWRI 1690, generates 0.3% v/v less ethanol than its parent, N96, while maintaining similar fermentation performance as its parent. Although this decrease in ethanol concentration might be small, we are confident that the overall experimental strategy works. We should also keep in mind that nature took some 20 million years to evolve highly efficient fermentation in yeast and we are attempting to reverse some of this evolution in the relative blink of the eye.

Using genetic engineering, we have developed more than 60 different yeast strains with altered metabolism; we have focused on genes that, at least potentially, impact on ethanol production. Specifically, we have increased the activity of genes that divert carbon away from ethanol production and/or deleted or down-regulated genes that contribute to ethanol formation. To date, two GM strains have shown considerable promise. Strain AWRI1631-A was able to decrease ethanol concentration from 15.7% v/v to 12.2% v/v, whereas AWRI1631-B lowered ethanol content from 15.7% v/v to 13.3% v/v, in both Chardonnay and Cabernet Sauvignon juices. Glycerol concentration increased 4.4 and 3.5-fold respectively, while acetic acid increased to 0.5 g/L for AWRI1631-A and remained at 0.2 g/L for AWRI1631-B. Both strains produced relatively high levels of acetaldehyde.

Although the Australian wine industry does not use genetically modified organisms (GMOs) for the production of Australian wine, we use GM technology since it will i) enable the identification of targets for non-GM approaches to wine yeast strain development; ii) show how far we can push the low-ethanol phenotype in wine yeast without compromising quality; and iii) deliver the best 'low-ethanol' producing strains in readiness for adoption by winemakers if/when the industry and consumers are accepting of GMOs.

As part of a more comprehensive approach to reducing alcohol levels in wine, the AWRI has also developed a 'Fact Sheet' with recommendations for grapegrowers and winemakers on a range of approaches for consideration when attempting to control ethanol yields in wine. The information provided was gathered from the collective expertise of practical grapegrowers, viticulturists, winemakers and scientists, and is based on experience and review of current scientific data. The fact sheet is available from the AWRI website and has been made available to the industry through articles published in the June issue of the AWRI's *Technical Review* and in the July/August issue (2010) of the *Australian and New Zealand Wine Industry Journal*.

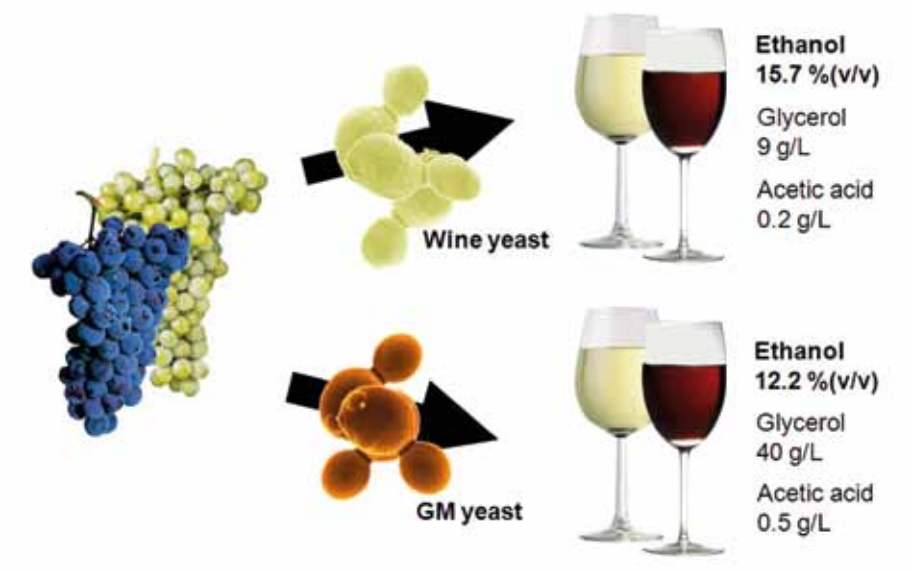


Figure 12. Ethanol production in Chardonnay and Cabernet Sauvignon wines produced using a wine yeast and its GM variant. Compared to its wine yeast parent, the variant (AWRI1631-A) produced 3.5% v/v less ethanol with a considerable increase in glycerol levels

Figure 13. Opportunities and recommendations for the lowering of alcohol concentration in wine

Wine flavour diversity through the generation of interspecific wine yeast hybrids

Historically, wine was produced by the spontaneous (wild) fermentation of grape juice; indigenous yeasts populated the must and the resultant fermentation was a product of the waxing and waning of many different microorganisms. Nowadays, winemaking relies heavily on the practice of seeding a commercial fermentation with an inoculum of a single yeast strain. Selected strains of *Saccharomyces cerevisiae* have long been the preferred choice for their robust fermentation traits and ability to impart desirable sensory properties to wine. However, the wines produced using a single *S. cerevisiae* strain are often considered to be less complex when compared to wines from spontaneous fermentations. The diversity of flavour profiles observed in wild ferments is associated with the many different organisms participating in the fermentation, each contributing their own metabolites towards the flavor profile of the resultant wine. Many winemakers would like to produce wines of greater complexity but are hesitant to run the gauntlet of a wild fermentation with an unknown microflora.

The AWRI 'Hybrid wine yeast' project is designed to generate yeast strains that combine the proven qualities of single *S. cerevisiae* inoculated wines with the flavour and aroma complexity of wild ferments. New wine strains are generated by hybridising an existing robust, commercial *S. cerevisiae* wine yeast strain with other, non-*cerevisiae*, members of the *Saccharomyces* group; *Saccharomyces* species are genetically diverse, but share a common mating system and are able to mate with each other. Interspecific hybridisation between different *Saccharomyces* species occurs in nature and yeasts bred by utilising the mating process are therefore considered 'natural'. The hybrid cell contains the genomes of both species and the fermentation process is now a product of their combined metabolisms, thus generating a larger range of flavor and aroma compounds during vinification.

New hybrid strains are screened for their robust fermentation traits and desirable flavor and aroma attributes prior to industry trials that are undertaken with local and interstate wineries. Wines from these trials have been showcased in the workshop, 'Winemaking with non-conventional yeast', at each of the 12th, 13th and 14th Australian Wine Industry Conferences. A number of white and red grape varieties have been used successfully in these trials: Chardonnay, Semillon, Viognier, Pinot Grigio, Fiano, Merlot, Cabernet Sauvignon and Pinot Noir, and the wines have been compared to wild fermentations carried out in the same grape juice. During the 13AWITC workshop, an evaluation of Chardonnay wines demonstrated the hybrid-made wines as having a more complex wine profile with a range of different flavours and aromas, than the wine yeast parent-wine that had a simple profile of tropical notes: flavour and aroma profiles of savoury, peach, banana, floral and nutty for AWRI 1503 (*S. cerevisiae* X *S kudriavzevii*); creamy, lemon rind, peach, pear and violet for AWRI Fusion (*S. cerevisiae* X *S. cariocanus*); savoury, pineapple, lemon rind, tropical and floral for AWRI Cerebay (*S. cerevisiae* X *S. bayanus*).

Team reports

To date, two interspecific hybrid strains have been commercialised and are available as Active Dried Yeast (ADY) products from Mauri Yeast Australia (Figure 14): AWRI 1503 and AWRI Fusion, while a hybrid strain, AWRI Cerebay, has also been commercialised by Mauri Yeast but is not yet available as an ADY product.

Improving robustness of wine yeast to minimise the risk of sub-optimal fermentations

Sub-optimal fermentations, including stuck and sluggish, are a perennial problem for winemakers the world over. While some of the causes of these troublesome fermentations are known and can be addressed by winemakers, mostly they continue to be a major drain on resources, are very costly and may impact negatively on wine quality. Therefore, the development of yeast strains that are more robust in the face of 'difficult' grape juice or challenging fermentations conditions would be of enormous benefit to producers; such yeast would be less likely to be recalcitrant when the going gets tough.

Toni Garcia-Cordente and Anthony Borneman

Stress-tolerance in yeast is generally regarded as a reasonable indicator of robustness, and has been an area of interest for the yeast research community for many years. Much of the focus of this work has been to understand the genetic basis of stress tolerance. Laboratory strains of *Saccharomyces cerevisiae* have been the workhorse in much of this work and, as a result, many variants of laboratory strains have been identified with enhanced stress-tolerance attributes. Unfortunately, these laboratory strains are inherently less stress-tolerant than their industrial relatives.

Figure 14. Two of AWRI's interspecific hybrid strains commercialised and available as Active Dried Yeast products from Mauri Yeast Australia

Researchers at the AWRI are currently evaluating the effect of previously identified stress-tolerant genes from laboratory yeast strains on the ethanol tolerance and fermentation performance of wine yeast. The project utilises the wine yeast strain AWRI 1631, which was recently sequenced at the AWRI. The aim of this is to establish whether these previously identified genetic determinants of stress-tolerance contribute to robustness in a wine yeast.

This work is being undertaken by two visiting PhD students: Sara Landolfo (Università Politecnica delle Marche, Italy) and Rocio Gomez Pastor (Institute of Agrochemistry and Food Technology, Valencia, Spain), under the supervision of staff at the AWRI. Preliminary results indicate that at least some genes that confer ethanol tolerance in laboratory strains of *S. cerevisiae* are also capable of increasing ethanol tolerance of wine yeast. This paves the way for the development of wine yeast strains with increased robustness, which will be less likely to produce sub-optimal fermentations.

Developing of a Chardonnay Juice Bank to better understand the causes of sub-optimal fermentations

During the 2009 vintage, the AWRI in partnership with The Yalumba Wine Company undertook a survey of grape juice composition focusing on Chardonnay. Our focus on this variety was driven by a desire to better understand variation in juice composition for one of Australia's most cultivated grape varieties, that is often associated with difficult or sluggish fermentations. The aim of this work was to:

- better understand the variation of Chardonnay composition as a whole and with regard to point of origin;
- better understand if and to what degree variations in composition affect fermentation outcomes; and
- build a juice bank of comprehensively characterised juices at the AWRI that would become a resource for those interested in further investigating the relationship between juice composition and fermentation.

The project took advantage of the high number of Chardonnay juice batches processed at Yalumba and the diversity of regions from which Yalumba sources its grapes. During the 2009 vintage, samples from 100 juices were collected immediately prior to initiation of fermentation. Winescan data for all juices were collected, as well as Winescan compositional information together with spectral scans of the fresh juice. All juices are being stored in glass at -20°C.

It was somewhat surprising that the minimum yeast assimilable nitrogen (YAN) observed in any of the juices was no less than 150 mg/L. This meant that all the juices contained sufficient nitrogen to support adequate fermentation and the majority had more than enough nitrogen to support a vigorous fermentation. Previous work in relation to the impact of elemental composition, predominantly in the brewing and distillation industries, suggests that trace elements can be limiting in certain situations, to the point that fermentation performance is affected. With this in mind, we

Cristian Varela and Simon Schmidt

also measured the elemental composition of all of the 100 juices in the bank by ICP-MS and AES. These data are currently being used to test what effect the maximal and minimal concentrations of trace elements have on a wine-like fermentation using a model juice; the effect of variations in trace elements composition on fermentation performance is the subject of ongoing work.

Comparative genomics reveals what makes wine yeasts special

As evidenced with larger domesticated species such as cats and dogs, human intervention has also shaped the physical attributes of the wine yeast *Saccharomyces cerevisiae*. Over the thousands of years that yeast has been used in industries such as winemaking, brewing and baking, its genetic makeup has been systematically transformed through the preferential selection of yeast strains with desirable or advantageous characteristics. As different industries prefer yeast strains with different properties that are desirable for that industry, these domestication events have produced large numbers of *S. cerevisiae* strains with a broad range of highly specialised phenotypes that suit very specific applications.

All of the phenotypic diversity that exists among these yeast strains is ultimately determined by differences in their genes, and comparative genomics provides a means to characterise and document these differences. For comparison, we sequenced the genomes (i.e. determined the DNA sequence) of five wine yeasts and two ale yeasts, and were also able to use genomic data from single laboratory, pathogenic, biofuel, wine and natural isolates of *S. cerevisiae* generated by other research groups (five additional strains in total). The genome (DNA) sequences of these twelve diverse strains were then compared.

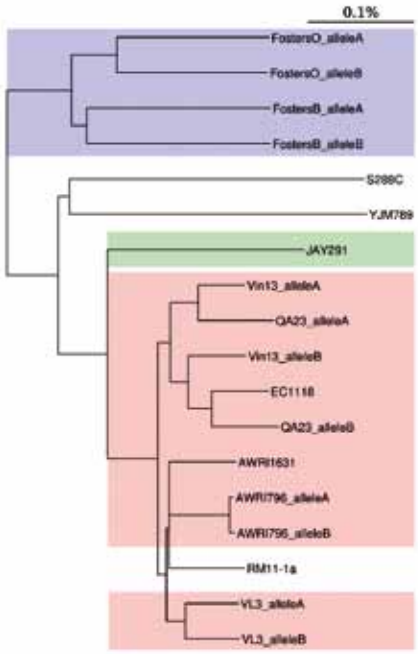


Figure 15. Neighbour joining tree representing the genetic distance between and within industrial yeast strains as calculated from their genome sequences. Industrial strains are colour-coded based upon their primary industry (wine, pink; ale, blue; bioethanol, green)

All of the strains investigated were found to be different from one another, but strains used within the same industry generally shared more genetic features than strains in different industries (e.g. wine strains share more features with other wine strains) (Figure 15). Interestingly, industrial strains were sometimes very different from each other. This was the case with the wine and brewing strains, which, despite their shared roles in the production of fermented alcoholic beverages, were just as distantly related from each other as they were to non-industrial strains such as those used in the laboratory.

While many of the genomic features that separated strains were represented by changes in individual DNA bases, there were also numerous instances where these features represented entirely new genes which potentially provide yeast strains with new enzymes or properties not found in other strains. One of these features included a cluster of 20 genes that were found specifically in one of the wine strains. These genes were predicted to encode a variety of functions. Of particular interest are three genes predicted to encode enzymes with aryl-alcohol dehydrogenase (AAD) activity. AAD enzymes are involved in the metabolism of ketones and aldehydes and may therefore provide strains that contain these genes with novel flavour and aroma producing profiles.

Overall, these datasets provide unmatched insight into what it takes to make a wine yeast, but our knowledge of the wine yeast genome is still far from complete. As genome sequencing technology advances and the genomes of more strains (including wine and other strains) become available, it will enable fine grained knowledge of how genomic differences translate into phenotypic outcomes. This will provide the basis to systematically produce wine strains with specific combinations of desirable properties.

AWRI Wine Microorganism Culture Collection

Culture collections play a vital role in preserving and conserving microbial biodiversity, and they are an essential part of the infrastructure underpinning life sciences and biotechnology. The prime role of the AWRI wine microorganism culture collection (AWRI WMCC) is to collect and store wine yeast and bacterial isolates to ensure the microbial genetic diversity, which is part of the grape and wine world, is not lost and is available to the wine industry and researchers.

The AWRI WMCC is an extremely important and valuable resource for Australian wine producers. It contains over 1900 yeast and bacterial strains including reference strains, winery isolates, research strains and experimental isolates. Most of the collection is available for research projects, but can also be obtained for winemaking purposes.

The AWRI Wine Biosciences team has used the AWRI WMCC in many research projects. One example is the 'Brett' project which examined over 200 Australian *Dekkera bruxellensis* isolates to determine their genetic variation across most Australian wine regions. *D. bruxellensis* is infamous as a causative agent of 'Band-aid®' or 'medicinal' character in red wine. Genetic analysis of the Australian *D. bruxellensis* isolates revealed eight different fingerprints, with one fingerprint, or genotype, found commonly across Australian wine making regions (Figure 16) (AWRI publications #880a, 989, 993, 1072). This study showed that the degree of genetic diversity amongst wine isolates was much greater than previously thought, and there was evidence of a considerable level of phenotypic diversity.

This project on *D. bruxellensis* led to the implementation of winery practice guidelines that have directly brought about a significant reduction in the incidence of 'Brett' spoilage in Australian red wine. Isolates representing the full genetic diversity of Australian 'Brett' are maintained in the culture collection so that, if there is a future outbreak of this spoilage yeast, AWRI will be well prepared to develop new strategies to tackle a recurrence of the 'Brett' problem.

An additional service the AWRI WMCC provides is the provision to preserve and store wineries' own yeast and bacteria isolates which can be accessed for future use; several Australian wineries currently store their yeast and bacterial strains in the AWRI collection. The advantages of depositing and storing yeast and bacterial strains into the AWRI WMCC include: reducing the expense of maintaining and storing microorganisms; deposited strains will be maintained by staff with specialised expertise in the appropriate storage conditions; and access to the strains is free.

Processing steps to optimise wine quality and development in bottle

Staff and students

Dr Liz Waters, Dr Martin Day (from 1 December 2009), Dr Matteo Marangon, Dr Maurizio Ugliano, Steven Van Sluyter, Mariola Kwiatkowski, Ken Pocock (until 15 September 2009), Dr Simon Schmidt, (AWRI); Nick Warnock (PhD student, Flinders University)

Collaborators

Flinders University (Dr Peter Anderson, Dr Ian Menz); Foster's Wine Estates (Dr Vanessa Stockdale); INRA UMR-SPO, France (Aude Vernhet); Nomacorc PL, Belgium (Olav Aagaard, Jean-Baptiste Dieval, Stéphane Vidal); Pernod Ricard Pacific (Leon Deans, Kate Lattey); University of Adelaide (Professor

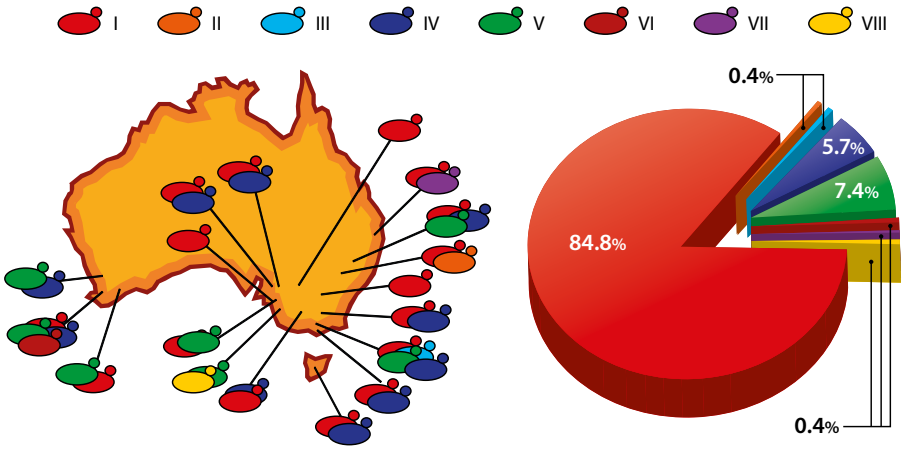


Figure 16. Grouping of Australian wine *Dekkera bruxellensis* strains based on their DNA fingerprint and their distribution across Australian wine regions (from AWRI publication #1072)

Brian O'Neill, Professor John Carver, Sam Stranks); University of Melbourne (Professor Antony Bacic, Dr Filomena Pettolino); University of Padua, Italy (Marco Lucchetta, visiting PhD student); University of Queensland (Dr Robert Falconer)

The main aim of this suite of projects is to improve winemaking processes after fermentation. The current focus is on two broad areas: protein stabilisation and bottling. We are also exploring the identity of compounds responsible for coarseness in white wines. This information is a pre-requisite for optimising wine processing strategies to manage this negative attribute in white wines.

Protein stabilisation

Preventing protein haze is a major white wine production issue. The current method of bentonite fining is effective, but has disadvantages associated with both efficiency and cost. Protein haze is caused by a relatively low concentration of grape pathogenesis-related proteins, namely, thaumatin-like proteins (TLPs) and chitinases. These proteins unfold and aggregate, resulting in light-dispersing particles and visible haziness. This year, we have focused on achieving a deeper understanding of the mechanisms of aggregation and precipitation of these proteins.

(LtoR) Martin Day, Steven Van Sluyter, Elizabeth Waters.
Location: Hickinbotham Roseworthy Wine Science Laboratory (WIC East)

Matteo Marangon and Steve Van Sluyter investigated unfolding of the protein structure by using differential scanning calorimetry. This technique allows us to determine the temperature at which compounds change, or, specifically in the case of proteins, when they 'melt' out of the structure they were in and into another conformation. We worked with Dr Robert Falconer at the Australian Institute for Bioengineering and Nanotechnology, University of Queensland, to determine the 'melt' temperatures of the grape proteins (AWRI publication #1187). In a simple wine-like solution, one of the TLPs 'melted', or began to unfold, at 62°C.

When the solution cooled, most of the TLP protein refolded again, on subsequent heating the protein unfolded again; the unfolding was reversible. One of the other grape proteins that cause haze, a chitinase, 'melted' at a slightly lower temperature and this denaturation was irreversible; the protein unfolded, aggregated, and precipitated out of solution. The data from these proteins in very simple model solutions suggest that the chitinases have a half life in wine of six minutes at 55°C and, extrapolating down to more normal commercial conditions, a half life of three days at 35°C or two years at 25°C. These times fit quite well with our observations (AWRI publications #943, 1004) that six out of eight commercial unfined wines stored at 16-20°C developed haze within a year of storage, the other two wines within three years, and that all of the wines were hazy after storage at 37°C. The TLP that melted at 62°C is more robust, with a calculated half life of 300 years at 25°C. These data suggest that chitinases might be more important to haze formation in wines than the TLPs. These sophisticated techniques to look at protein unfolding also suggest that denaturation of the proteins, or loss of their structure, is a necessary first step before aggregation could occur.

We also used another approach to understanding haze formation to confirm the importance of the unfolding reaction. By collaborating with Professor John Carver at The University of Adelaide and Sam Stranks, a Physics and Chemistry Honours student, we used turbidity data from heat tests to develop a mathematical model that describes the aggregation process. This modeling work showed that an activation step was required before any aggregation happened, and consistently with the conclusions reached using a biophysical approach with Robert Falconer, this activation step is most likely heat-induced unfolding. What all these studies are pointing to is that protein unfolding is likely to be the most important step in aggregation, and that it might also be the rate-limiting step, particularly for the thaumatin-like proteins. Understanding how and why unfolding occurs is, thus, critical to understanding haze formation and developing new ways for the wine industry to deal with this problem.

One of our other questions has been whether precipitation and aggregation of the unfolded TLPs and chitinases is linked (co-precipitation) and whether there are differences between how the two classes of proteins form haze in wine.

The hazing behaviour of chitinases and TLPs was studied by Matteo Marangon under different conditions, from the most complex matrix (real wine), to simpler systems (protein free ultrafiltered wine and model wine; both spiked with purified grape proteins). Results from a heat test of the protein free ultrafiltered wine spiked with different amounts of purified TLPs and chitinases show that the haze formed was linearly correlated to the chitinase content. Sulfate was naturally present in the protein free ultrafiltered wine, but the addition of 2 g/L sulfate resulted in a higher haze formation. The same experiment was performed using a model wine spiked with purified proteins. After a heat test, very little haze was formed in absence of sulfate corroborating the idea that sulfate is required for haze formation. The correlation between chitinase content and haze formed after the heat test was confirmed. In presence of sulfate, chitinases fully precipitated upon heating, while only a small portion of TLPs precipitated. 'Real haze' was induced by storing an unfined wine at 30°C for 22 h. This induced little protein precipitation and modest haze. In this wine and under these conditions, chitinases were the main proteins precipitating.

The melt temperature of TLPs and chitinases was shown to be affected by the medium in which protein were dissolved in, with the proteins melt temperatures being approximately 2°C lower in ultrafiltered wine than in model wine.

These data indicate that:

» chitinases are the dominant protein in haze from real wine and are the most prone to precipitate; there is a linear relationship between chitinase concentration and the amount of haze formed;

» sulfate was confirmed to have a role in modulating haze formation by converting soluble aggregates into visible haze particles; and

» the differences in melt temperature observed between model and real wine confirms that the stability of chitinases and TLPs is greatly affected by some non proteinaceous compounds of the wine matrix.

One of the main theories tested was the fact that TLPs and chitinases, being usually found in hazes together, could have a precipitation behavior that is somehow linked. Overall, this theory has not been entirely disproved for real wines, but has been shown to be negligible.

These results are consistent with data from biophysical studies but some detail needs to be confirmed. Some of our experimental conditions were tailored to capture the quick unfolding behavior of chitinases, while TLP unfolding could be much slower or follow a different precipitation pathway under longer-term storage conditions that occur commercially. However, the data described above suggest that chitinases play a major role in protein haze in wine and that future research into bentonite alternatives could benefit from focusing particularly on removing chitinases.

It also appears likely that protein unfolding is the key to successfully using proteases in wine to degrade these proteins. An unfolded structure might make the peptide backbone more accessible to a proteolytic enzyme. We are now in an excellent position to optimise heat treatment of juice and wine to facilitate proteolysis, because we have a much deeper and more detailed understanding of how these proteins respond to heat in terms of their structure and at what temperatures these changes occur. Preliminary studies undertaken by Steve Van Sluyter with short-time/high temperature heat treatments and proteolytic enzymes have confirmed that we can reduce concentration of unstable grape proteins. Our progress this year has provided us with insightful fundamental information about white wine protein haze and has opened up many exciting possibilities to reduce haze with less bentonite.

Oxygen management at bottling and during bottle storage

Wine composition has an important part to play in how oxygen exposure will shape a wine's development. To illustrate this concept, Maurizio Ugliano and Mariola Kwiatkowski, in collaboration with Tracey Siebert, Mark Solomon and Dimitra Capone of the aroma chemistry team, have undertaken a study on Sauvignon Blanc wine and varied the levels of copper and glutathione present at bottling. Why have we focused on copper and glutathione? Copper is particularly commercially relevant because it is commonly added at bottling to prevent 'reductive' aromas, but it is also well known for its role in promoting oxidation. We were interested to explore its effects on oxidation in general and on oxidative losses of the 'good' sulfur compounds responsible for the varietal aroma characteristics of Sauvignon Blanc, like 3-mercaptohexanol (3-MH). Glutathione, a sulfur containing tripeptide, was of interest because it is naturally present in wines and is an antioxidant. Its levels can be augmented by winemaking practices such as the use of yeast products enriched in glutathione and by yeast lees ageing.

We found that oxygen exposure, copper addition and glutathione all significantly affected the concentration of 3-MH. Increased glutathione levels generally resulted in wines with increased 3-MH. Conversely, increased copper concentration generally decreased 3-MH concentration and most of the copper effect occurred at bottling. Oxygen exposure also had a significant influence on 3-MH, with lower exposures resulting in less loss of 3-MH. This effect was generally smaller than the one associated with glutathione. Other studies have investigated the influence of oxygen exposure on 3-MH changes during bottle storage, concluding that increased oxygen exposure, for example by using closures with higher oxygen transmission rates (OTRs), can be detrimental to 3-MH concentrations. However, at least under our experimental conditions, addition of glutathione appeared to offer greater potential to preserve 3-MH than reducing oxygen exposure, although a combination of both low oxygen exposure and glutathione (GSH) addition preserved the greatest amount of 3-MH. This indicates that, while it is generally accepted that oxidation of aroma compounds during storage is due to excessively high OTR, wine composition plays a role that can be at least as important as OTR.

One of the 'bad' sulfur compounds, H_2S, was also detected in the wines at concentrations above threshold, after a period of bottle storage. H_2S has been associated with 'reductive', rotten egg-like aromas in wine. As we saw for 3-MH, significant differences in the final concentration of H_2S were observed in response to changes in glutathione, copper and oxygen exposure. In general, wines with added glutathione always exhibited higher H_2S concentrations than their corresponding untreated samples. Given the antioxidant capacity of GSH, this higher accumulation of H_2S could be due to the lower degree of oxidation occurring in these samples. Oxygen exposure determined large variations in H_2S content, with the highest H_2S concentrations generally observed in wines with the lowest oxygen exposure. This is consistent with the generally accepted idea that extremely low oxygen exposure, such as that achieved by using screwcap closures, can sometimes result in conditions favouring the development of unwanted reductive aromas.

Surprisingly, copper addition systematically increased final H_2S concentrations, particularly when combined with low oxygen exposure. This observation is somehow unexpected, as copper addition prior to bottling is widely carried out in the wine industry to remove reductive off-flavours related to the accumulation of H_2S and mercaptans. Moreover, copper is a well known pro-oxidant, another factor which in theory should have resulted in a decrease in H_2S. Nevertheless, studies in other food matrices have shown that metals, including copper, can promote desulfurization of different substrates, for example, cysteine, with consequent release of H_2S, in particular, in the presence of catalysts such as pyridoxal or pyruvate. This might explain the positive relation observed here in Sauvignon Blanc wines between copper and H_2S and will be further explored.

These data suggest that wine compositional factors, such as metals and glutathione content, can determine the ability of a wine to develop H_2S during storage. At the same time, oxygen exposure is a powerful modulator of H_2S accumulation. The nature of the chemical and biochemical processes, determining H_2S accumulation during ageing, remains to be established.

This work provides a first direct comparison among some compositional and technological variables that are able to affect white wine aroma development during bottle ageing. In general, the effect of compositional parameters such as glutathione and copper content on wine 3-MH content was higher than that observed for oxygen exposure. This emphasises the importance of fermentation and post-fermentation practices to the management of wine post-bottling aroma stability. In particular, while glutathione appears to offer significant improvements in the control of 3-MH degradation during time, copper is clearly detrimental to the concentration of this key aroma compound. On the other hand, glutathione, particularly in combination with copper, also induces conditions favourable to the accumulation of powerful off-odour compounds such as H_2S. Oxygen exposure can be seen as a modulator of these major trends, with low oxygen exposure preserving 3-MH but also favouring accumulation of H_2S. Therefore, management of wine oxygen exposure by closure selection should be considered in light of the compositional characteristics of the wine.

Given the complexity and variability of the wine matrix, the results of this study, although obtained in real winemaking conditions, need further confirmation during trials with a larger number of wines covering a broader range of compositional characteristics and experimental conditions. Our results at this stage, however, suggest that the use of copper to remove and/or prevent reductive off-odours needs to be reassessed.

Leigh Francis and Patricia Osidacz

Wine in society

Wine quality and consumer needs

Staff
Leigh Francis, Patricia Osidacz, Belinda Bramley, Jason Geue, Brooke Travis (to February 2010), Helen Holt (from April 2010)

Collaborators
University of South Australia (Professor Larry Lockshin, Dr Simone Mueller); SensoMetrics (Mark Stevens)

The sensory research team plays a pivotal role in numerous projects across the technical and research activities of the AWRI. The team has extensive experience in design of sensory experiments and in controlling the myriad of details to ensure sensory data are effectively collected and interpreted in a rigorous manner. The sensory team is also skilled in recruiting, training and managing panels. The AWRI is one of a handful of organisations to have four types of assessors available for regular sensory studies. We have a large pool of screened tasters who are routinely asked to evaluate samples in difference tests, such as triangle or duo-trio tests. We also have a highly experienced group of 16 technically trained expert tasters who specialise in identifying off-flavours, faults and taints, as well as giving quality scores in sessions that run at least weekly. The assessors who are involved in the largest number of studies are our sensory descriptive analysis panelists: 13 people specially selected from wine consumers in the local community. These tasters have been trained to rate intensities of defined attributes in an objective manner, and two-hour sessions are run three days a week. The final set of assessors we have available consists of untrained typical wine consumers, and we have a large database of consumers, from which 100 to 200 people are called in for particular tests as needed.

Whilst working with other AWRI teams, many individual sensory studies have been completed over the last twelve months, and results of these are presented elsewhere in this report. These have included projects investigating:

- malolactic bacterial strain differences in Cabernet Sauvignon, Pinot Noir and Merlot;
- the longevity of sensory differences among Cabernet Sauvignon wines made with different malolactic bacteria;
- Sauvignon Blanc wines bottled with and without added glutathione, added copper, air in the headspace, as well as storage either anaerobically or in air;
- Shiraz wines made from vines treated with different levels of urea fertiliser, or with diammonium phosphate added in the winery;
- the influence of several yeast strains on warm climate Chardonnay wine flavour;
- the effect of nutrients on Adelaide Hills Chardonnay sensory properties;
- smoke-affected wines from the 2009 Victorian bushfires;
- aroma detection threshold values for volatile phenol compounds implicated in bushfire smoke taint in a red wine base;
- the perception of smoke related flavour from phenolic glycosides;
- two sets of red wine samples from a project assessing microoxygenation and bottling/storage atmosphere at two time points post-bottling;
- a commercial closure shelf life project, with Commercial Services, with three studies completed to date;
- aroma detection thresholds for the sulfur compounds methane thiol and hydrogen sulfide in white and red wines; and
- a series of wines for the Pinot Grigio/Gris project with Industry Applications to establish values for a consumer oriented style scale.

The technical quality panel has assessed 399 wines over the year, apart from control and training samples mainly for Industry Development and Support and Commercial Services clients. The panel also plays a major role in screening large numbers of research samples as the first stage of a formal sensory study.

Team reports

A large sensory descriptive analysis and consumer preference study included the addition of key Sauvignon Blanc flavour compounds to a neutral white base wine. The project was part of Ellena King's PhD project. Each of the 'tropical' thiols studied contributed to 'tropical' and 'cat pee/sweaty' attributes, depending on concentration, with the thiol 3MHA being of particular importance. The 'green' attributes were primarily related to the presence of isobutyl methoxypyrazine (IBMP), which had the ability to dominate strongly the other components, but it was found that the thiols also contributed to these attributes.

'Confectionery', 'tropical', 'cat pee/sweaty', 'cooked green vegetal' and 'fresh green' aromas were the main sensory attributes influencing acceptance for different groups of consumers. Liking of 'green' flavour, in particular, polarised consumers, with one consumer cluster, comprising 43% of the tested consumers, preferring the wines containing IBMP, while another group (31%) liked these wines the least. Optimal levels of esters and volatile thiols were shown to exist for two clusters.

The study provided practical guidance to wine companies regarding appropriate levels of these components in Sauvignon Blanc wines. Importantly, models were generated that allowed prediction of the different sensory attribute intensities, given knowledge of volatile compound concentration and, in turn, make it possible to predict consumer liking from the intensity of the key sensory attributes.

Two other studies have been completed involving additions of flavour compounds to a base wine working with the flavour chemistry team.

The first assessed the effect of eucalyptol (mint, camphor, eucalyptus), rotundone (black pepper) and guaiacol (smoky) at moderate and high levels added to a red wine base. The sensory properties were determined by the sensory descriptive panel and 104 Adelaide consumers tasted the wines and gave liking scores. There were three groups of consumers with similar preferences identified by cluster analysis, with roughly equal proportions of consumers in each group. Figure 17 shows the results of the consumer testing.

The consumers in cluster 1 liked least the wines with added eucalyptol. Cluster 2 consumers disliked the high guaiacol wine, while Cluster 3 very much preferred the base wine with added eucalyptol. The addition of rotundone had little effect on the consumers' preferences. The results provide guidance regarding whether these compounds, and at what level, might be regarded as objectionable by consumers. Further work is required with other base wines and, with guaiacol, the presence of related compounds to more realistically assess the effects on quality as perceived by consumers.

In a second addition study, the sulfur-containing compounds hydrogen sulfide, methane thiol and benzyl mercaptan were added on their own and in combination at two different levels to a base white wine. The results of a sensory descriptive analysis study showed clearly that benzyl mercaptan was the sole contributor to a 'struck flint' aroma, while hydrogen sulfide was the cause of 'boiled egg' aroma. A sensory attribute 'rotten/sewage' involved the presence of both hydrogen sulfide and methane thiol. The results point strongly to benzyl mercaptan as a reason why some wines develop a reductive 'struck flint' flavour after some time in bottle.

Compositional data have been analysed from two large recent red wine sensory-consumer studies and the most important volatiles contributing to the sensory attributes of the wines have been assessed. These results significantly add to our limited understanding of red wine fruit flavour and it is apparent that both fermentation derived compounds and grape components are involved. Components associated with fruit aroma common to both studies were several acetate esters as well as vanillin, 5-methyl furfural, beta-damascenone and beta-ionone. The relative absence of oak volatiles, 4-ethylphenol and 4-ethylguaiacol, sulfur compounds, ethyl acetate and isobutyl methoxypyrazine was also important to fruit intensity, presumably due to masking effects. Other interesting relationships were found, such as green flavour with levels of methoxypyrazines, and cooked vegetal flavour with DMS.

An investigation was conducted to assess the effect of wine exposure on the preferences of novice or low involvement wine consumers. More than 200 Sydney consumers assessed six Shiraz wines, three lower priced and three higher priced, in a central location test. Following this, the consumers undertook a home use test assessing a single Shiraz wine on five occasions, with a final central location assessment of the same six Shiraz wines.

The study showed that consumer preferences, especially those of recent wine consumers, changed through short-term repeated exposure to the same red wine. Long-term consumers were not affected by their experience with a simpler, softer wine but those who were exposed to a more strongly flavoured, tannic and complex wine changed their preferences substantially. They also enjoyed the richer wine more at home than in the laboratory setting. Importantly, recent wine consumers changed their flavour preferences towards the style of wine to which they were exposed; recent consumers who were exposed to the premium wine reduced their preference for the simpler wine.

This study indicates that if novice consumers are given opportunities to sample unfamiliar wines, their preference can move from lower priced to higher priced wines, and that this effect is important in the short-term, rather than requiring years of tasting experience. This has significant implications for companies investing in cellar door or wine fair type tastings, and exposure is likely to be an important effect in emerging markets such as China for consumers not used to Australian wines.

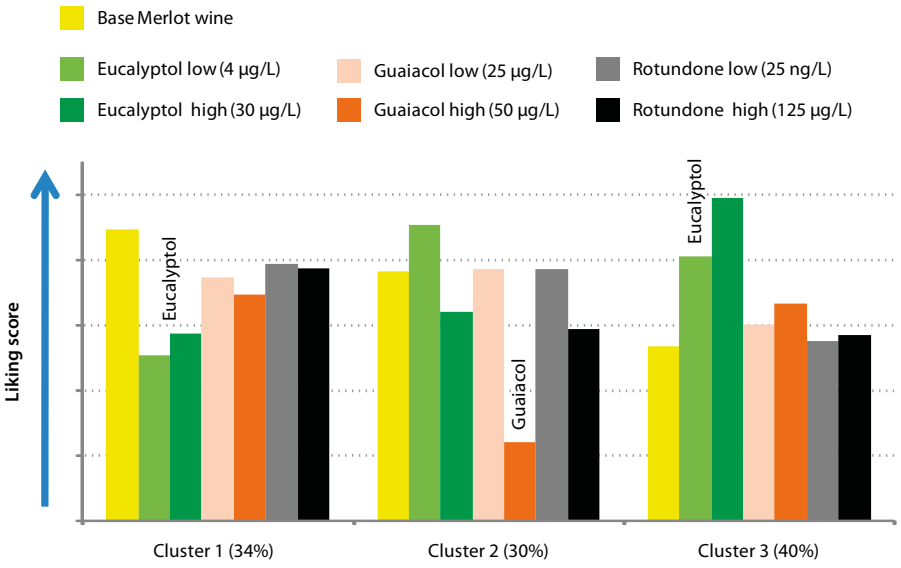


Figure 17. Consumer liking scores for a Merlot wine with added flavour compounds. 104 Adelaide regular red wine consumers assessed the wines blind

Human health, nutrition and food safety issues impacting on the Australian wine sector

Staff
Creina Stockley

One of the activities of the AWRI has been to provide health and nutritional advice and assistance to the Australian wine sector, through Creina Stockley, the Health and Regulatory Information Manager. From 1 July 2009 until 30 June 2010, 65 information, health and nutrition requests were received by the Health and Regulatory Information Manager from industry, the general public and government.

Committee membership
During the year, support to the sector has been derived from the Health and Regulatory Information Manager's membership of the following government and industry committees: the National Drug and Alcohol Research Centre's Young People and Alcohol Project Advisory Group; the National Alcohol Knowledgebase Expert Working Group; and the Winemakers' Federation of Australia Wine and Social Responsibility Committee. She is also the DAFF-nominated Australian delegate for the Organisation International de la Vigne et du Vin (OIV) Health and Safety Commission (IV), and is currently the President of the Food Safety Expert Group. She is also a member of the honorary editorial board of the *International Journal of Wine Research* (Dove Medical Press), a charter member of the International Scientific Forum on Alcohol Research and a member of the Scientific Board of the [European] Wine Information Council.

Health and nutrition issues
During the year, the database of research on the beneficial and detrimental health effects of alcohol, and in particular wine, has been added to and these records are available online for levy paying members of the Australian grape and wine sector. This is facilitated by the subscription to relevant medical and scientific journals, and by the formal and informal exchange of information between complementary organisations, both national and international. The journals have been regularly scanned, and articles have been prepared for inclusion in the AWRI's publication, *Technical Review,* and for other Australian wine sector and international alcohol industry newsletters. Articles and other material have also been prepared for the electronic and print media (see Appendix 5). For example, three articles have been prepared for the monthly *Australian and New Zealand Grapegrower and Winemaker* and *AIM-Alcohol in Moderation,* and an article for the bi-monthly *Technical Review,* as well as a chapter in the book entitled *Red wine and health* published by Nova Publishers. In addition, a 10,000 word chapter entitled *The biology of intoxication* for the book entitled *Expressions of drunkenness (Four hundred rabbits)* to be published by Routledge on behalf of DrinkWise Australia and the International Centre for Alcohol Policies was prepared with Professor John Saunders of the *University of Queensland.* Four media interviews were conducted (see Appendix 4).

The Health and Regulatory Information Manager also acted as a consultant for the Winemakers' Federation of Australia submissions to the Australian government's *Issues consultation paper: food labelling law and policy review* and to the Thai government's proposal to introduce health warning labels for alcoholic beverages.

In addition, she prepared a project application for funding entitled *Determination of the beneficial cardiovascular effects of red wine and the three primary wine-derived phenolic compounds and their metabolites in humans* with Professor Arduino Mangoni of the University of Aberdeen, Scotland, UK for the Alcohol Education and Rehabilitation Foundation. Funding for this project has been granted. Another project application entitled *Tracking the metabolome of grapes into wine* has been prepared with Professor Fulvio Mattivi of the Edmund Mach Foundation, Italy. This project aims to identify, quantify and potentially characterise compounds in grapes that are transferred to wine which may have therapeutic effects in humans, in order to demonstrate the role of wine as part of a healthy diet and lifestyle. The Health and Regulatory Information Manager has been included as an investigator on a project application entitled *An open label proof of principle study of resveratrol as a treatment for Friedreich ataxia* acting in the capacity as an expert on the pharmacology of resveratrol and its metabolites with Professor Martin Delatycki of the Heidelberg Repatriation Hospital, Melbourne.

Invited presentations (see also Appendix 1) were made at the University of Adelaide's Wine 2030 Wine and health workshop on 23 November 2009, the Organisation de la Vigne et du Vin (OIV) Commission IV Expert Group meetings in Paris, France on 8-13 March 2010, and at the University of Aberdeen and Rowett Research Institute, Aberdeen, Scotland, UK on 18 March 2010. Presentations were also made at the Fourth International Conference on Polyphenols and Health in Harrogate, Yorkshire, UK on 7-11 December.

In addition, the Health and Regulatory Information Manager has continued her part-time external PhD program in the Faculty of Health Sciences at Flinders University entitled *It is not per capita alcohol consumption that matters but per occasion alcohol consumption.*

Project coordination
The project entitled *Resveratrol in the chemoprevention of colorectal neoplasia* funded by Cancer Australia has commenced. Professor Finlay Macrae Head of the Department of Colorectal Medicine and Genetics at The Royal Melbourne Hospital and the AWRI's Health and Regulatory Information Manager, are the Co-Chief Investigators of the project. The project is investigating whether grape-derived resveratrol, administered in a moderate amount of red wine, reduces the risk of developing bowel cancer in human subjects. The effect of resveratrol on proteins and cell mechanisms involved in controlling cell growth and thus cancer potential will be measured from blood samples and from tissue samples taken from the bowel.

Compilation, interpretation and communication of issues pertaining to responsible use of agrochemicals in Australian viticulture

Staff
Dr Sally-Jean Bell, Marcel Essling

Eleven thousand copies of 'Agrochemicals registered for use in Australian viticulture 2010/2011' were produced and the booklet made available for download from the AWRI website. The booklet (commonly known as the 'Dog Book') was also inserted into the Annual Technical issue of the *Australian and New Zealand Grapegrower and Winemaker.* Four agrochemical updates were prepared and posted on the agrochemical website and sent to AWRI email subscribers. These listed new agrochemical products registered for use in viticulture, advised industry that the Australian Pesticides and Veterinary Medicines Authority (APVMA) had removed grapes from the label of all products containing the active constituent carbendazim, announced that the 2010/2011 booklet was available and outlined the major changes. In addition, documents outlining chemical control options for 6 spotted mites in Western Australia and control options for snails and mealy bug in vineyards were developed. An extensive review of the agrochemical article, featuring the agrochemical booklet tables and accompanying text, was undertaken for *Australian Viticulture.*

A joint Winemakers' Federation of Australia / AWRI submission to the APVMA was prepared on behalf of the wine sector in regards to the restrictions around the use of 2,4-D. The functionality of the Online Agrochemical Search Facility was reviewed and further refinements were proposed. Work was commissioned that will allow the user to define a particular growth stage when searching for products available for use on a specific target, thus taking into account a specific recommended withholding period for export grapes. A presentation with speaker's notes and an article for the workshop booklet on changes to the 2010/2011 'Dog' book was developed for the Vine Health Field days being organised by the National Extension Manager at the

National Grape and Wine Industry Centre. This presentation along with 'Best practice botrytis management' was delivered at The Queensland Viticulture Seminar-Winter 2010 in Stanthorpe on 23/06/10 (Appendix 1).

Wine and field study data, submitted by a chemical company who had registered an application to support a change to the recommended withholding period for tetraconazole, was reviewed by the AWRI. Following the review, a comment was prepared in response to a Trade Advice Notice by the APVMA in regards to the proposed registration of Samurai for mealybug control. The APVMA 'off-label' permits for the agrochemical website was updated. The AWRI agrochemical and MRL databases were updated. The maximum residue level (MRL) database was reviewed and a further 16 countries' residue specifications were added to the existing database of 22 countries.

The Senior Viticulturist attended the GWRDC-facilitated workshop 'Assessing the economic cost of pest and disease control in Australian Viticulture' on 3 August 2009 in Adelaide and two presentations entitled 'Updates and issues related to the 2009/2010 publication *Agrochemicals registered in Australian viticulture'* and 'Resistance management in viticulture' were given at a Peter Lehmann's Pest and Disease Seminar Day on 2 September 2009.

During the year, the agrochemical staff dealt with 255 enquiries regarding the use of agrochemicals for pest and disease control, the persistence of residues through winemaking and their effects on fermentation, and issues related to maximum residue limits in overseas markets. These enquiries comprise 78% of the total viticulture enquiries received. The Senior Viticulturist and Viticulturist dealt with 75% and 25% of the 'agrochemical-related' enquiries respectively.

Regulatory, technical and trade issues impacting on the Australian wine sector

Staff
Creina Stockley

One of the activities of the AWRI has been to provide regulatory and technical advice and assistance to the Australian wine sector, through the Managing Director, the Health and Regulatory Information Manager and the Industry Development and Support group of which the Health and Regulatory Information Manager is a member. During the year, 125 independent regulatory, science and technical-related information requests were received by the Health and Regulatory Information Manager from the wine sector, the general public and government.

Industry committee membership
During the year, support to the wine sector has been derived from the Health and Regulatory Information Manager's membership of the Winemakers' Federation of Australia (WFA) Wine Industry Technical Advisory Committee and the Wine Industry National Environment Committee. The Health and Regulatory Information Manager is also a Department of Agriculture, Forestry and Fisheries-nominated Australian delegate for the Organisation International de la Vigne et du Vin (OIV) Expert Group meetings.

Technical and regulatory issues
The technical and regulatory support to the Australian wine sector is ongoing as issues are regularly raised by industry or government, both in Australia and internationally, and often span several years. During 2009/2010, technical and regulatory information and/or issues that have been reviewed, and material prepared includes: the relevance and the role of Australian research into genetically modified organisms and related issues for the Australian grape and wine industry; phosphonate ions/phosphonic acid in wine; implications and issues of natamycin residues in grapes and wine; incidence and potential for mycotoxins such as fumonisin B2 and ochratoxin A in Australian wine; and the potential contamination and concentration of bisphenol A in wine. In addition, a submission to the Australian Pesticide and Veterinary Medicines Association (APVMA) was prepared in conjunction with the viticulturists and the WFA on reconsideration of label approvals for products containing 2,4-D. In addition, an invited presentation was provided to the inaugural Corkwise wine seminar at Campden/BRI in Surrey, UK on wine quality and safety regulations (Appendix 1), and input was also provided to a presentation on a need for internationalisation and standardisation of analytical methods for wine for the Australian Wine and Brandy Corporation/WFA Wine Australia - Regulations and innovation program conducted in China. One article has been prepared for the monthly *Australian and New Zealand Grapegrower and Winemaker,* and two articles for the bi-monthly *Technical Review* as well as one article for the peer-reviewed *Annals of Microbiology,* in conjunction with the Senior Research Scientist-Microbiology (Appendix 5).

In addition, the Health and Regulatory Information Manager continued as a member of two OIV working groups—*Protocol for the evaluation of the risks related to food safety for new oenological treatments* and *Taskforce on allergens,* of which she is chair. The former encompassed preparation of a 'decision tree' and accompanying protocols for evaluation of the risks related to food safety of new oenological treatments, to facilitate the future adoption of new oenological treatments by the OIV, and by Food Standards Australia New Zealand to which the OIV is a reference body. The aim of the latter has been to coordinate analytical and clinical research into the potential for residual protein in protein-fined wine and its significance for human health, which has been undertaken by Australia, France, Germany and Italy. A further extension of the temporary derogation was granted. A second submission to the European Commission and the European Food Safety Authority to provide for a permanent derogation for wine on allergen labelling for egg and milk products has been subsequently prepared and submitted.

Furthermore, the information in the AWRI database on approved additives and processing aids for winemaking in Australia and internationally has been updated and made available on the AWRI website.

The Health and Regulatory Information Manager also coordinates Course 3005WT *Grape industry practice, policy and communication* for the School of Agriculture, Food and Wine at The University of Adelaide. In its fifteenth year, 14 students enrolled in the Course, which exposes students to organisational, commercial, environmental, political, societal and technical issues relating to the wine sector's operating environment.

Industry Applications

Staff
Peter Godden, Paul Smith, Daniel Cozzolino, Richard Muhlack, Wies Cynkar, Ella Robinson, Nevil Shah, Bob Dambergs and Emma Kennedy

Collaborators
Bruker Australia (Andrew Bales), CAMO Australia (Brad Swarbrick), Cellarmaster Wines (Mark Robertson); Constellation Wines Australia (Chris Bevin); McGuigan-Simeon (Bruce Kambouris); CSIRO Entomology (Stephen Trowell, Amalia Berna); CSIRO Land and Water (Anu Kumar); DPI Queensland (Heather Smyth); James Cook Univeristy (Danny Coomans, Yvette Everingham), Jeffress Engineering (Colin Jeffress), Orlando Wines (Kate Lattey, Leon Deans); Petaluma Wines (Andrew Hardy, Mike Mudge), SARDI (Tom Madigan, Mike McCarthy, Joanne Pech), Tamar Ridge Wines, Tarac Technologies (Mark Anderson), Thermo (Glenn Grayston), Treasury Wine Estates (Allen Jenkins, Pascal Marty, Paul Petrie, Brenton Porter, Allen Hart, Kevin McCarthy, Eric Wilkes); University of Adelaide (Steve Tyerman, Eileen Scott, Belinda Stummer, Peter Ashman, Philip van Eyk, Adam Kosminski, Elizabeth Cooter, Roberta De Bei, Sigfredo Fuentes, Wendy Sullivan, Kerry Wilkinson); University of South Australia (Miguel de Barros Lopes), Victoria University (Grant Stanley), The Yalumba Wine Company (Greg Edwards, Cecil Camilleri, Andrew Murphy, Geoff Linton, Simon Dillon)

The Industry Applications (IA) Group essentially takes primary responsibility for the 'D' in the AWRI's R,D,E&C model. The team works closely with other

AWRI teams, external research collaborators and with industry partners to more effectively bridge 'gaps' that might exist between research and application, break down barriers to uptake and multiply the value of existing investment. The IA group pro-actively assists wine industry personnel to apply practical knowledge generated both inside and outside the AWRI. Identifying the barriers to application of knowledge and research outcomes is critical, for example, in determining whether there is a technical solution that is missing, or perhaps a requirement for more education and awareness around a topic. Demonstration of the financial and sustainability benefits that come from knowledge application is also crucial, as is the development of new products and technological solutions that arise from research programs. In a global R&D marketplace and an era of cross-border ownership, Australia's continued success will be linked to its ability to apply new technology rapidly; speed to market is a key consideration.

The IA team focuses on four main areas, among which there is substantial integration:

» Economic and Environmental Sustainability and Process Improvement

» Regionality

» Smart Technologies

» Integrated Solutions

Planning for environmental and business sustainability

At this time of continued global economic instability, the Australian wine industry is under intense pressure on many fronts. Rising energy costs, together with currency volatility, finance costs, and credit availability are all impacting on bottom-line profitability. Water shortages are a real and immediate threat and continue to be of growing concern across all sectors of the community. Meanwhile, the Garnaut Climate Change Report reinforces the significant risk that climate change poses to Australia and to agricultural-based industries in particular. Market and social pressures relating to carbon footprint, emissions trading, food-miles, and biodiversity further add to the mix.

However, the AWRI firmly believes that a world 'beyond carbon' is possible and attainable for the Australian grape and wine sector, and is positioning itself to assist the industry to make the transition. Lasting sustainability can be achieved if we change our behaviours and adopt different courses of action. An approach to the dual challenges of climate change and sustainability is required, which encourage long-term solutions, a vision where economics and sustainability go hand in hand; the assumption that 'going green' always loses money must be challenged by demonstrating that the return on the investment in doing so outweighs the costs.

(LtoR) Ella Robinson, Richard Muhlack, Karl Forsyth.
Location: Hickinbotham Roseworthy Wine Science Laboratory (WIC East)

Process improvement and efficiency gains across a range of areas will be critical to the sustainability response, and so the AWRI's work to develop practical tools and solutions to support this are gaining momentum. By involving government and industry stakeholders, and collaborators and partners at the Wine Innovation Cluster (WIC), more effective support and leadership is being provided in pursuit of its long-term sustainability vision.

For example, engineering tools and process knowledge are available right now to meet the environmental sustainability needs of business. Potential winery process areas where significant high impact and/or low cost improvements are typically possible include refrigeration control, process heating and waste heat recovery, hot water generation, air compressor performance and wastewater treatment. Producers who adopt these initiatives early will be well placed to benefit profitably from their investments in sustainability.

As one example, it is well documented that between 50% and 70% of most wineries' energy use is for heating or refrigeration. However, when water is heated for bottling purposes, much of it is flushed down the drain instead of being recycled back into the production cycle. Modeling conducted by the AWRI has shown that simply reusing hot water for pre-heating or other purposes could potentially save wineries up to 30% of their water heating bills – resulting in environmental and economic benefits. Other recent engineering studies conducted by the AWRI have also shown that operating with brine temperatures that are excessively cold can have a significant negative impact on refrigeration energy costs and consequent carbon emissions. Increasing brine temperatures can give energy savings of more than 20% in some cases without impacting on the overall effectiveness of the refrigeration system.

Likewise, adjustments to cellar storage temperatures, tank insulation quality and fermentation conditions can also lead to significant savings. Work has commenced on developing real-time data monitoring combined with a suitable process model, which might be used in computer simulations to identify and predict problem fermentation behaviour before it occurs. Our aim is to enable winemakers to take the necessary corrective action. The AWRI is continuing to develop and refine its hybrid simulation models to provide robust performance against commercial fermentation data across all scales of fermentation size. Enhancements to the current models to better predict yeast lag phases and non-uniform tank mixing, are also being explored, and will be incorporated into pilot models for industry testing and evaluation in vintage 2011.

Opportunities also exist to add value to winery processes and waste streams through renewable energy technology such as the generation of electricity from process biomass, liquid biofuels and solar thermal systems. Through 2009, the AWRI conducted a scoping study (funded by the Australian Government Department of Agriculture, Fisheries and Forestry) of grape marc and stalks as a fuel source for low-emissions renewable power generation using combustion and fluidised-bed gasification technology. Marc gasification testing in a circulating fluidised bed gasifier found that favourable gas composition and carbon conversions were achieved under typical industrial process conditions (see Figure 18). However, a high level of potassium in the resulting ash was observed which, whilst common with biofuel processing, has potential for so-called 'agglomerate formation' and equipment fouling (see Figure 19). A possible mechanism for agglomerate formation was proposed where potassium carbonate (K_2CO_3) formed in the char, reacts with silica from the bed

material leading to the formation of molten potassium silicates. These high potassium levels are likely to present challenges in terms of fluid-bed fouling on a larger scale and so counter-measures will be required. Potential mitigation strategies include fluid-bed additives and alternative (non-silica) bed materials.

High-level techno-economic comparison of gasification versus anaerobic digestion (another potential biofuel technology) suggests gasification as the more favourable technology despite higher capital cost, due to greater efficiency and improved energy conversion arising from the gasification process. However, economics will be highly dependent on process scale and site requirements, and further work in this area is required to firm up recommendations of costs versus benefits of various technologies.

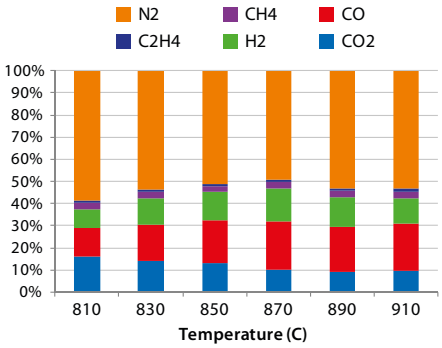


Figure 18. Gas compositions during grape marc gasification

The AWRI has been working to develop resources to highlight high impact sustainability improvements such as these, and to assist the wine sector to overcome adoption barriers that impede uptake of these opportunities. Central to this is the AWRI's new environmental web portal, which was launched at the 5th Australian Wine Industry Environment Conference. The web portal allows users to search the AWRI's dedicated database of environmental articles; use the dedicated Environment Search Engine to search across multiple relevant websites in one place; or to browse a range of specially-selected links clustered by topic. Web-based fact sheets and excel-based calculators have been developed for a range of the improvement initiatives described, and can also be accessed via the web portal. Those fact sheets and calculators demonstrate threshold capital costs and annual process cost savings for different facility sizes.

Innovative application of these opportunities will allow our industry to further improve resource recovery, reduce costs, and minimise environmental impact. Such initiatives will be crucial to maintaining our competitive advantage while we adjust to the carbon constrained economy of the future.

Helping to define regionality

The Australian grape and wine industry is regionally diverse, and has a demonstrable ability to produce an equally diverse range of wine types, and within-varietal wine styles. However, there is little objective data or information available which elucidates the factors that influence regional differences, or data that allows an understanding of Australian regional wine styles in a global context. In addition, climate change is likely to have an effect of shifting current regional style. Industry Applications projects have the potential to plot such shifts, thus potentially allowing grape and wine producers to mitigate the impact of climate change or even harness it for improved wine quality; a beneficial change in wine style or objective definition of styles; or the development of novel wine styles within their region.

Producers, exporters, regulators and consumers are all demanding analytical tools for cost-effective routine quality control of wine. The quality of wines primarily depends on the type of grape, climate, soil, and the different techniques used during the cultivation and production process. Wines produced in specified regions are clearly identified and controlled by different governing bodies at both the national and regional level. Furthermore, a wine produced in a specific region with well-defined cultivation and elaboration practices verifiable by the competent bodies is awarded in the EU as the Denomination of Origin (DO). Additionally, geographical denominations bring many advantages to producers and consumers, such as protecting these products from possible frauds, guarantee high product quality standards, and define strict production protocols, regulations and policies for production. Geographical denominations also potentially play a role in preserving the environment, with the quality and composition of a given product being strictly linked with the production environment and traditions.

Non-sophisticated techniques and direct measurements, like visible (VIS) and infrared (IR) spectroscopy, combined with multivariate data analysis techniques, have demonstrated the ability to characterise wines through rather simple procedures. The main advantage of this approach is simplicity and robustness of the procedure that relies on the pattern recognition system (e.g. principal component analysis or discriminant techniques). However, the complexity of these statistical tools negatively affects the slightly improved classification rate because their implementation makes routine analysis rather difficult. The use of UV-Visible (UV-VIS), near infrared (NIR) and mid infrared (MIR) spectroscopy methods combined with chemometrics were explored to discriminate Shiraz wines produced in five Australian regions namely the Barossa Valley, Coonawarra, McLaren Vale, Clare Valley and Western Australia.

Rapid measurement of phenolics in grapes and wines

There is an emerging view that tannin measurements should be recognised as a standard part of creative, high quality winemaking, just like measuring pH, TA, alcohol and colour. In a dry red wine, tannins are the next most abundant group of compounds after organic acids, occurring in gram per litre concentrations. Research has shown that tannin *concentration* is largely determined by the timing of pressing, and from then on concentration doesn't change hugely. The way the tannin chemically evolves can change its sensory perception, as can changes in the wine matrix around it (e.g. alcohol, sugar, acid, polysaccharides). Depending on which types of tannins are represented in the tannin *concentration*, the wine's sensory perceptions at different stages of its life may also differ. Research into analytical measurements of wine tannin *composition* continues, but is challenging due to tannins' inherent chemical complexity.

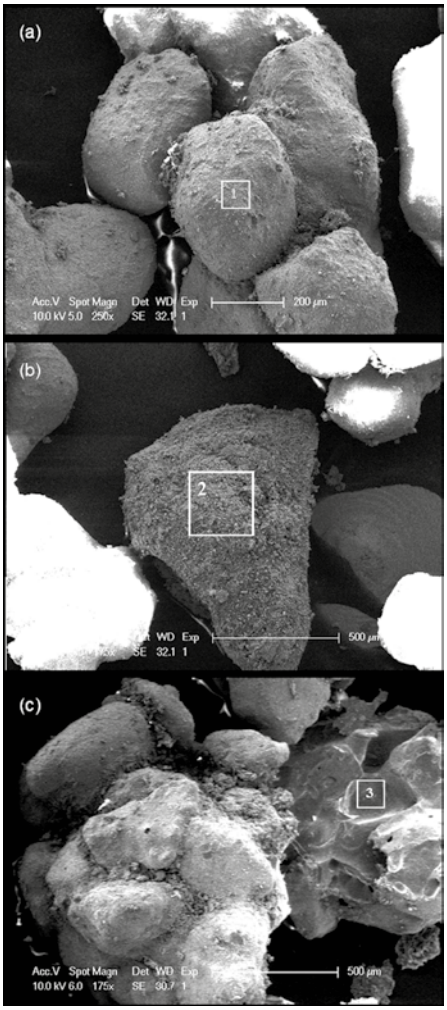


Figure 19. SEM micrographs of the bed from the gasification of grape marc at 860°C, including (a) ash coated bed material, (b) unburnt char particle, and (c) agglomerate fused joint

(LtoR) Nevil Shah, Paul Smith, Daniel Cozzolino.
Location: Hickinbotham Roseworthy Wine Science Laboratory (WIC East)

However, thanks to recent developments building on tannin research, analytically measuring wine tannin *concentration* is now well within reach of most winemakers. Making wines to an acid specification is a matter of routine — and now there is a user-friendly tannin assay which means that this class of compounds, so important to red wine structure, can also be more effectively managed during the winemaking process.

Applications such as the analysis of total anthocyanins in grapes, using Vis-NIR spectroscopy, have also been adopted in industry. To complement the analysis of anthocyanins it is desirable to also analyse tannin. The AWRI previously developed a simplified wet chemistry method (the 'MCP tannin method') to measure tannin in grapes and wine, and this has now been taken one step further through the development of rapid spectral methods using UV, Vis, NIR and MIR spectroscopy.

To maximise access for Australian practitioners to this rapid predictive method for tannin, a web-based interface was launched at the start of 2010. Known as the 'AWRI tannin web portal', it uses six wavelength values from a UV-Vis spectrophotometer to calculate tannin, total phenolics and total pigment (colour) values, which are the three most important phenolics values. Sample preparation is simple, results are available straight away and the hard work of maintaining a calibration is taken care of by the AWRI. Users just dilute samples in acid, leave them for three hours, and then read the absorbance at the specified wavelengths. The absorbance readings are entered into a web interface which returns results for these values immediately. A quality control (QC) process is built into the system, and users are provided with a QC standard to measure with every batch analysed.

The 'AWRI tannin web portal' allows winemakers to quickly determine tannin concentration in their own facilities as long as they have a single-read or scanning UV-Vis instrument. Such instruments are widespread in the Australian industry. A 'benchmarking' function in the portal also allows the client to recall any of their previous vintages' results and compare with results from the current vintage. In addition, results can be put into broader context by accessing the built-in database of tannin values from more than 3000 Australian red wines that are searchable by vintage, region and variety. This means that single pieces of data can more easily be turned into knowledge to support the decision-making process. Tannin is a driver of wine style and regional character and this means that winemakers who are trying to define a certain character, or to characterise a particular region or style, can use tannin concentration as part of the answer.

While a method using a standard UV-Vis spectrophotometer may be advantageous for a smaller laboratory that does not have access to NIR or MIR devices, using the IR wavelength regions has the advantage that many other analyses can be performed simultaneously. For example, we have now demonstrated that with the same Vis-NIR scan, anthocyanins, tannins, total dry matter, water content, total soluble solids and pH can be rapidly measured in red grapes. As appropriate equipment and software becomes more affordable and more versatile, these methods are expected to become main-stream in industry.

Affordable, multifunctional instruments for rapid grape and wine analysis

AWRI research has long demonstrated the capacity of spectroscopy to rapidly predict multiple grape and wine composition parameters. However, inadequate availability or access to affordable spectroscopy instruments that have been robustly tested for use with grapes and wine has slowed the widespread adoption of these methods. To address this, the Industry Applications' (IA) Rapid Analytical Methods (RAMS) team is partnering with other businesses to ensure the availability to the Australian industry of affordable instrument solutions.

The availability of affordable, 'off-the-shelf' spectroscopy instruments is improving. One such mid-infrared (MIR) instrument with an ATR cell that is easy to clean and maintain, has been used by the IA team in the field during the last two vintages. This instrument, a Bruker Alpha, was used to demonstrate that yeast assimilable nitrogen (YAN) could be predicted rapidly and used to track ferments and inform decisions relating to nitrogen (DAP) supplementation. Wine yeast utilise ammonia and alpha-amino nitrogen during fermentation, known collectively as YAN. YAN is required for the synthesis of proteins, cell wall components and enzymes. Insufficient YAN in the juice/must can result in sluggish or stuck fermentations and the production of hydrogen sulfide. A simple and fast MIR spectroscopy method was developed for simultaneously determining total soluble solids (TSS, °Brix), pH, total phenolics (TP), ammonia, free amino nitrogen (FAN) and yeast assimilable nitrogen (YAN) contents in grape juice samples using attenuated total reflectance (ATR). A juice calibration built in 2009 was used to predict YAN in 2010 juice samples and the prediction was good, with an error (~10%) very similar to the error (~10%) of the enzymatic reference method (see Figure 20).

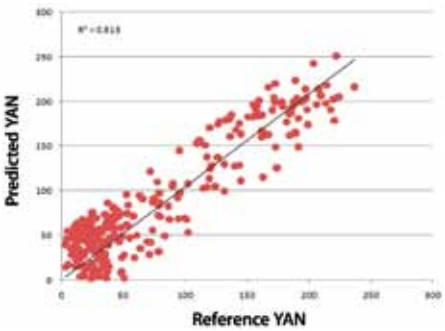


Figure 20. Shows the validation results for samples collected during 2010 vintage predicted using the PLS calibration for YAN developed in 2009

The time required for analysis, the cost, and the volume of samples required were considerably reduced compared to the transmission MIR measurements currently commonly used by the wine industry. The practical implications of this study showed that ATR-MIR spectroscopy offers valuable benefits for the Australian wine industry, and that it provides a rapid tool to monitor the fermentation process in the winery. This method also offers the possibility to develop relationships between spectra and reference methods in order to measure several parameters simultaneously, thereby reducing analysis time and consequent cost, with minimal sample preparation required.

When 'off-the-shelf' spectroscopy instruments for a particular application are not available, custom design is required. One such example is the BevScan instrument for rapid, non-destructive in-bottle analysis, which will be launched at the WineTech exhibition at the 14th Australian Wine Industry Technical Conference.

The BevScan is an innovative new device to analyse and classify wines without opening the bottle or disturbing the contents. Of particular interest to winemakers, manufacturers, bottlers, distributors, retailers and auction houses, BevScan is expected to find wide acceptance in applications as diverse as beverage quality control, monitoring and optimising wine distribution conditions, wine authentication, identification of wine deterioration due to storage and or the closure used, and wine substitution detection, bottle by bottle.

The device uses a simple beam of light passing through the bottle as its measuring technique, thus providing an environmentally-friendly process requiring no chemicals, consuming very little power and leaving the wine or beverage totally unaffected. BevScan has been specifically designed for use by less experienced operators, making the testing very cost-effective.

A product of local South Australian Company, Jeffress Engineering Pty Ltd, and with spectroscopic techniques developed in conjunction with The Australian Wine Research Institute, BevScan is the result of five years of research and uses VIS-NIR spectroscopy to determine the constitution of wine and bottle. Statistical processing support was provided by CAMO AS of Norway (makers of *Unscrambler* software). The device employs sophisticated electro-optics, computers and statistical mathematics hidden behind a simple touch screen interface to provide easy to interpret results signaled with 'traffic light' style indicators.

The unique power of BevScan depends on a locally-developed technology called SimCal. By analysing a small number of known 'good' or 'target' bottles of wine with BevScan, a similarity signature (SimCal) is derived, against which unknown bottles are then compared. A SimCal value or 'score' is determined for each unknown sample and either a match or mismatch is signaled by a simple red/green indicator and an easy-to-understand graph on the touch screen. A reading can be completed in just a few seconds, so large numbers of samples can be processed quickly using the device. The first demonstrated application is for detecting sporadic oxidation in white wines and further applications are under development.

Adrian Coulter and Ed Carr (Constellation Australia). Location: Constellation Australia vineyard, Reynella

Rapid measurement of plant water status

The collaborative study between four Wine Innovation Cluster (WIC) partners (AWRI, SARDI, The University of Adelaide and CSIRO) to integrate different methods to assess and manage water in the vineyard, is progressing. NIR calibrations developed were validated and yielded good correlation coefficients between predicted and measured stem and leaf water potential for a second vintage.

Understanding Pinot Gris and Pinot Grigio wines

In a world-first, Australian producers of Pinot Grigio and Pinot Gris wines have access to a simple labeling device which informs consumers the 'style' of the wine in the bottle at point of sale or before opening.

Called the *PinotG Style Spectrum*, the label indicates to consumers whether the style of the Pinot Grigio or Pinot Gris wine is 'crisp' or 'luscious' or somewhere on the spectrum of possible styles in-between. Additionally, the labeling device will potentially help remove the confusion which results from the common use of the two names for the same variety, which are often difficult to relate to the style of the wine in the bottle. So why is there confusion about Pinot Grigio/Pinot Gris wine style? Traditionally, the styles of wines produced in northern Italy and labeled Pinot Grigio have been crisp and zesty, with wines from Alsace, labeled Pinot Gris being luscious and rich in texture. In Australia, an extraordinary range of Pinot Grigio/Pinot Gris wine styles are being produced, with some being crisp and zesty, others luscious and rich in texture, and others again showing every conceivable combination of those characteristics. The *PinotG Style Spectrum* is intended to give consumers greater confidence in choosing a Grigio or Gris wine based on their own style preference.

The *PinotG Style Spectrum* has been developed by The Australian Wine Research Institute (AWRI), in collaboration with some of Australia's leading wine producers.

To qualify for a label, the wine is 'fingerprinted' by the AWRI, which quantifies where on the scale (between 'crisp' and 'luscious') the particular wine sits. The label is easy to understand for consumers who enjoy drinking Pinot Grigio and Pinot Gris wines (Figure 21).

Figure 21. The PinotG Style Spectrum scale will help give consumers greater confidence in choosing a Grigio or Gris wine based on their own style preference

Wine producers who want to investigate the option of using the *PinotG Style Spectrum* label on their Pinot Grigio or Pinot Gris wine bottles should contact Peter Godden at the AWRI (email: peter.godden@awri.com.au).

In summary, the Industry Applications team is driving the development processes needed to ensure these technologies are combined into packages which have relevance to industry – what we term 'integrated solutions', and these 'integrated solutions' are beginning to be adopted by industry.

Information & knowledge transfer

Winemaking and Extension Services — Technical problem solving and consulting

Staff

Adrian Coulter, Matt Holdstock, Geoff Cowey, Gayle Baldock, Emma Kennedy, Con Simos, Yoji Hayasaka.

The Winemaking and Extension Services team provide a range of services to the Australian wine sector; such services includes a range of advisory, problem solving, extension and information services. In addition to its extension and information transfer activities, which are discussed elsewhere in this report, the Winemaking and Extension Services team provides a technical problem solving and analysis service to levy-payers within the Australian wine sector. The primary aim of the service is not only to provide diagnoses of various problems, but to offer preventative and remedial advice based on the cumulative problem solving and practical winemaking experience of the staff. As previously reported, it is clear that quality loss during wine processing and packaging represents a major cost to the Australian wine sector. Consequently, all the activities of the Winemaking and Extension team, in terms of problem solving, extension and information transfer, aim to address this issue in a targeted manner. This is exemplified by the taint investigations undertaken which were the catalyst for the development of a preventative workshop titled 'The avoidance of taints and chemical instabilities during winemaking'. This workshop was delivered to wine regions around Australia; our current workshop titled 'A guide to trouble free bottling for winemakers' aims to provide winemakers with tools and knowledge to prevent problems surrounding the packaging of wine products – problems which we address many times each year.

The technical problem solving and analysis service represents a significant proportion of the team's workload and is provided according to strict Terms and Conditions. Client confidentiality is an important aspect of the provision of the services. This facilitates a frank exchange of information between the AWRI and its clients, which in turn allows the maximisation of the knowledge gained from the provision of these services. If a particular problem is considered to be of interest to the wider wine sector, the results of investigative work are made available through relevant publications, including the Winemaking and Extension Services team's regular contribution to *Technical Review*. A follow-on from this, in recent times, has been the collection of wines associated with these interesting investigations. These wines are currently presented as part of a 'real wine tasting' during our current workshop (A guide to trouble free bottling for winemakers), which enables us to show the wider wine sector what can happen to packaged product when problems are missed prior to or during, the packaging of wines. The real wine tasting plays an important role in the practical component of the workshop. However, under no circumstances is the name of the winery or company concerned, or any possible identifying references, ever published or revealed.

A proportion of the investigations conducted by the team relate to disputes arising between levy-payers or between levy-payers and suppliers of either materials or contract services. Consequently, and with great sensitivity, Winemaking and Extension Services staff members often find themselves in a mediation role in these disputes, and spend a considerable amount of time providing technical information to legal professionals representing grapegrowers and wine companies. Fortunately, however, the majority of disputes are settled before formal court proceedings are instigated, which is of great benefit to clients.

Full reports, containing technical information relating to the problems investigated, are prepared for clients when investigations are likely to result in litigation and or insurance claims. Otherwise, clients are provided with summaries which seek to explain the underlying causes of the problems encountered, or are directed to relevant sections within the Winemaking and Extension Services section of the AWRI's website. Advice on how to prevent the re-occurrence of such problems is provided to clients and technical references relating to the area of investigation are also often supplied.

A summary of the number and type of investigations conducted by the Winemaking and Extension team over the past three financial years is presented in Table 1.

The number of investigations conducted during 2009/2010 is 7% higher than for the previous year, whilst the total number of samples analysed, as part of these investigations, has actually decreased slightly from the previous year. The number of investigations conducted into wines affected by hazes and deposits has disappointedly increased, with these types of problems continuing to represent a considerable percentage (35% for 2009/2010) of the total number of investigations performed. Consequently, issues related to such instability problems continued to be addressed by the Winemaking and Extension Services team during AWRI's Roadshow workshops and via the Winemaking and Extension Services section of the AWRI's website, where there is a webcast related specifically to identifying hazes and deposits.

The number (23) of investigations conducted into microbiological instabilities, has continued to remain low and decreased slightly from the number (27) for the previous year. This low number is relative to the period from 1999/2000 to 2004/2005, during which the average number of microbiological investigations conducted per year was 62. Despite the encouraging downward trend in the frequency of this type of investigation, a substantial number of wine samples continue to be received with microbiological instability, often resulting in a haze or deposit, or even spoilage in some cases, forming after bottling. Awareness around how to avoid these issues continues to be addressed at regional workshops, as bottling issues have represented a large proportion of the queries received by the Winemaking and Extension Services team in recent years.

There was a substantial increase in the number of investigations conducted under the category 'Sensory assessments' during the last financial year, and the number has remained high this year. A downward trend in the number of investigations conducted under this category was observed from the period 2002 to 2007, when the numbers of these investigations conducted decreased from 72 to 26. However, that downward trend has rapidly reversed over the past two years (Table 1). The types of investigations carried out under the 'Sensory assessments' category include those conducted into wines reported to be exhibiting 'reductive' characters or wines reported to be affected by 'unknown' or 'unusual' sensory

Table 1. Summary of the number and type of problem solving investigations conducted, and numbers of samples analysed by the Winemaking and Extension team during the past three years

Type of investigation	Investigations conducted and samples analysed		
	2007/2008	2008/2009	2009/2010
Identification of hazes and deposits	70	64	84
Microbiological investigations	19	27	23
Sensory assessments	33	67	70
Taint problems	58	31	23
Other investigative analyses	25	31	40
Closure-related investigations	4	6	1
Total number of investigations	209	226	241
Total number of samples analysed	1042	1042	1000

characters; wines showing 'deterioration' or bottle to bottle 'variability' after packaging; or wines that might have been the subject of a 'customer complaint'. Sensory evaluation is an important analytical and research tool, and is also commonly used in problem solving investigations classified under other categories, such as 'Microbiological investigations', 'Taint problems' and 'Other'.

The number of 'taint' investigations conducted has steadily decreased since the 2005/2006 financial year, when there was a 'spike' in the number due to investigations into 'plastic/chemical-like' taints, the majority of which were due to the use of a particular batch of tartaric acid that was tainted with 2,6-dichlorophenol. The number (23) of taints investigated in the past 12 months has continued the decreasing trend, and is still below the average figure (45). The number (23) of investigations in the past 12 months is the lowest number of taints ever recorded in a 12 month period (Figure 22). These data might indicate that, at least in part, the strategies for avoiding taints and contaminations advocated in the 'The avoidance of taints and chemical instabilities during winemaking' workshop, which we delivered as part of the AWRI's Roadshows from 2006 to 2009, are continuing to being adopted by the Australian wine sector.

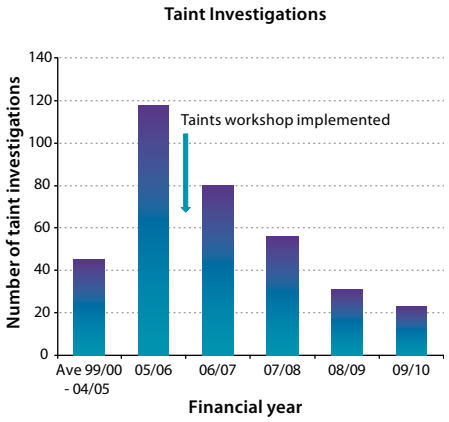


Figure 22. The number of investigations conducted into wines affected by taints during the period 2005/2006 to 2009/2010 and the average number of these types of investigations for the period 1999/2000 to 2004/2005

It is encouraging that only three post-bottling cork-type taint investigations were conducted during the year, suggesting that the incidence of this type of problem might be decreasing. Interestingly, two of these investigations involved contamination by 2,4,6-tribromoanisole (TBA) and not 2,4,6-trichloroanisole (TCA), which is the first time we have seen more confirmed TBA contaminations in wine than TCA contaminations. In one case, the contamination involved a sparkling wine which had been disgorged and bottled in batches, with one particular batch containing consistent but low level contamination of TBA. This suggested that the wine might have contained TBA, rather than the TBA coming from the closure. If the closure was the source of the contamination, then it is expected that a large variation in TBA concentration between the different bottles would be evident, as well as some with no TBA in them at all, however this was not the case suggesting that the source might not have been the closure. The source of this taint was never identified, however, it was suspected that the wine might have been contaminated externally by a processing aid or during the bottling process; a scenario that has been observed previously. The second investigation involved a number of products spanning a number of vintages from one particular winery, all suspected of containing a musty like taint and all bottled under screwcap. Three bottles of one product, across consecutive vintages (six bottles in total) were analysed and shown to contain a low level consistent TBA concentration in all bottles analysed. Further, different wines from the same winery, and the same vintage, were analysed and determined to contain low level TBA contamination also. The results so far have not revealed how the wines came to be contaminated, and thus the investigation is continuing to try and identify the possible source(s) of the contamination.

It is possible that the downward trend in the number of cork-type taint investigations conducted (in particular positive TCA contaminations), might be the result of the wine sector's increasing use of alternative closures to natural cork. However, it is concerning that musty type contaminations are still occurring, and even more so that these appear not to be related to the use of natural cork closure.

An investigation which highlights the ongoing battle with taints and contaminations, is an investigation which we performed for a winery who contacted us about a number of their wines exhibiting dull, musty and poor fruit expression after the addition of a particular fining agent. Analysis of the wines and the fining agents indicated the presence of TCA, and subsequently the fining agent was identified as the source of the taint. The continued monitoring of processing aids and fining agents is an area that all wineries need to continue to be vigilant, as the presence of any taints will lead to wine quality loss and potentially reputation and financial loss.

Winemaking and Extension Services staff continued to address the issue of smoke-derived taint during the year, in collaboration with the AWRI's Research team and the University of Adelaide. As indicated in last years' Annual Report, a research program was initiated to help us understand the relationship between free guaiacol and other smoke-related volatile organic compounds in grapes and wine. The contribution and significance of non-volatile smoke-related organic compounds to smoke-derived taint was also investigated during the year and the results of this research is discussed elsewhere in this report. A comprehensive workshop covering all the important issues associated with smoke-derived taint in grapes and wine was coordinated by the Winemaking and Extension Services team during the year for presentation at the 14th Australian Wine Industry Technical Conference. The program includes presentations from researchers from the University of Adelaide and the Department of Agriculture and Food Western Australia, as well as the AWRI. A number of tastings are also included in the workshop and include line-ups of 'real' smoke-affected wines, smoke-affected research wines and wines 'spiked' with key smoke-taint compounds recently investigated by the AWRI, which are discussed elsewhere in this report. A representative of the Western Australian Department of Environment and Conservation has also prepared a presentation outlining how the issue of prescribed burning is being tackled by the department and how they are working towards solutions with the wine industry. Winemaking and Extension Services staff also presented two seminars on the subject of smoke taint during the year.

For the third year in a row, investigations conducted under the category 'Other investigative analyses' have increased by greater than 25%. The types of investigations recorded under the category 'Other investigative analyses' are extremely varied, and include topics such as pinking problems; over fining with copper; flat sparkling wine; blue rinse water during bottling preparation; comparing laboratory results and fining trials; and possible substituted wine.

The declining trend observed in recent years for the 'Closure-related' category continues, with only one investigation in the past twelve months. This is an area in which Winemaking and Extension Services staff have been highlighting the issues for many years, so it is pleasing to observe a decline in the number of closure-related problems.

A summary of the enquiries received by Con Simos, Adrian Coulter, Geoff Cowey and Matt Holdstock for the year is shown in Table 2, with comparison figures for the previous two years.

Table 2. Enquiries received by Winemaking and Extension Services advisory staff in the period 2007/2008 to 2009/2010

	2007/2008	2008/2009	2009/2010
Wineries	1244	1024	829
Government organisations	48	36	19
Other	150	160	149
Students	18	16	4
Total	**1457**	**1236**	**1001**

Compared with the previous year, the figures for 2009/2010 show a 19% decrease in the total number of enquiries received. It is interesting to note that the figure for enquiries has decreased for wineries, however the figure for investigations (Table 1) has increased. The decrease in enquiries has largely occurred through the 'wineries' category and may partly reflect the consecutive decline in the winegrape crush since 2008 (down 17% cumulative). Nevertheless, the number of enquiries received from wineries is significant and indicates that a large number of Australian wine producers continue to regard the AWRI as a trusted, reliable, and an important source for quality technical information and problem solving solutions.

An access database for capturing the enquiries received for technical advice has been developed by the Winemaking and Extension Services team, and was implemented in January this year. The new system provides a platform for logging enquiries, which includes a brief description of the enquiry and the advice provided, but it also allows other data to be collected including winery size, state, region, and importantly is keyword linked, providing information which previously wasn't captured. A number of keywords have been developed around the previous enquiries over the years and can be used for identifying trends and potential topics for future workshops. The database currently only holds six months of data, but to show the potential benefits of this system, an example of some outputs are presented in Table 3. Being able to mine such a database can allow targeted dissemination of educational material, through avenues including workshops, website, *eNews* and *eBulletins*.

Table 3. Example of how the data can be used for identifying trends from particular states and regions. Data extracted from the Winemaking and Extension Services database January – June 2010

State	Number of enquiries received
ACT	2
NSW	99
QLD	12
SA	289
TAS	21
VIC	144
WA	87
Enquiries received from regions within WA	
Geographe	4
Great Southern	19
Margaret River	42
Pemberton	4
Perth Hills	5
Swan District	7
Keywords linked to Great Southern	
Microbiological	6
Analysis interpretation	1
Analysis methods	3
Smoke	2
Investigation follow-up	3
Fermentation advice	1
Taints and contaminations	2
Haze and deposit	1

Transfer of knowledge relating to winemaking

Staff

Con Simos, Geoff Cowey, Adrian Coulter, Matt Holdstock, Emma Kennedy, Sarah Ballantine, Virginia Phillips, Francesca Blefari (from 3 May 2010) and Ella Robinson

The technical problem solving services offered by the Winemaking and Extension Service team are supported by extension activities including: a national roadshow seminar and workshop program; AWITC workshop program; the Advanced Wine Assessment Course; Research to Practice®; web-based resources; and tailored workshops or seminars on request by sector associations. The team makes regular contributions to the AWRI's *Technical Review*, *eBulletins*, *eNews*, industry communication mediums and provides presentations for external seminars and conferences; contributes to the web-based technical reference manual and also provides 12 hours of lectures to Oenology students at the University of Adelaide (see the Appendices for further details).

The National Roadshow seminar and workshop program are currently made on a rotating basis to 37 locations covering Australia's winemaking zones and regions. The three year rotational program has been reviewed to ensure maximum industry coverage and meeting industry need. Outcomes from the review have seen the seminar program attending Griffith, once per year, and all remaining locations once every two years. The workshop program will continue to be presented over a three year period. The Roadshow schedule is available on the AWRI website and in *Technical Review*, as well as advertised through the national wine press, publications of ASVO, AWBC, and NWGIC and through the local wine association websites.

During the year, 16 days of roadshow seminars and workshops were held throughout Australian winemaking zones and regions including: Toowoomba, Geelong, Swan Valley, Griffith, Orange, Mudgee, Cowra (Canowindra), Coonawarra, Barossa Valley, Clare Valley and New England (Armidale). Orange, Mudgee and Canowindra were visited for the first time this year. The 2009 calendar year was our biggest year ever in terms of the number of events staged (an event was scheduled somewhere in Australia once every two weeks) and the numbers of participants in attendance.

Roadshows seminars are organised in conjunction with winemakers' and growers' regional associations. These associations select the presentations to be made from a range of research topics covered by the AWRI, in order that the seminars are closely tailored to the interests and needs of the audience. Seminars are presented by appropriate AWRI staff members based on the selected topics from all of AWRI's research steams. These presentations have been reviewed over the year to be focused on delivering 'take-home messages' to the audience. A range of new viticulture presentations have proved quite popular. Furthermore, a range of new presentations will be prepared over the coming year.

(LtoR) Peter Leske (La Linea), Matthew Holdstock, Nick Bruer (Richmond Grove Wines).
Location: Richmond Grove Winery, Tanunda

Roadshow workshops are presented by our winemakers, and are tailored to deliver practical winemaking advice to the wine sector in an interactive manner involving tastings; diagnostic tests and practical exercises. These workshops are developed specifically to manage current technical issues. This year saw completion of 'The avoidance of taints and chemical instabilities during winemaking' workshop which was developed to educate and inform Australian wine producers of taints that have affected the wine sector over the last few years. The launch of our new 'A guide to troublefree packaging for winemakers' workshop provides practical information regarding

Team reports

Geoff Cowey. Location: Adelaide Convention Centre, Adelaide

preparing wine for bottling, controlling microbiological activity, both through filtration and chemical measures, packaging operation, closure and package choice and wine storage and transport. The workshop was developed on industry request due to a gap in knowledge or available information resources regarding best practice packaging. The workshop has been run five times with positive reviews.

In addition to roadshow workshops, staff members presented a number of external seminars, tastings, or presentations at the specific request of industry bodies, this year including the Bendigo, New England, Rutherglen, Stanthorpe, Swan Valley Wine Associations, The Institute of Masters of Wine, Orlando Wines, South Australian Wine Guild, and the Interwinery Analysis Group (Appendix 1).

Seminars relating to heatwaves and processing ripe fruit were popular, with the following talks presented in different regions: 'Heat wave and stress in the winery', 'An overview of the impact of high grape sugar' and 'Processing ripe fruit - working with high sugars in the winery'. Presentations on wine flavours, those particularly influenced by climate change and/or the environment, were also given including 'Salt – current research and future directions', 'Topical flavours – smoke, eucalyptus character and pepper flavor' as well as analytical presentations such as 'Comparing cold stability methods'. Presentations given featuring tastings included 'Riesling - composition, flavours, styles and consumers and closure choice', 'Real wine tasting of bottling related faults', and a 'Riesling and Tempranillo production' masterclass.

The team also offers information and responds to current sector issues, in publications throughout the year (Appendix 5). The article entitled 'Smoke taint – A summary of the work relating to the 'Black Saturday' fires in Victoria and the response by team AWRI' was published in the August issue of *Technical Review* (#181). An article entitled 'When it all goes wrong - treatment and disposal of juice, wine and lees waste material' was published in the March issue of the *Australian and New Zealand Grapegrower and Winemaker*. This completed a series of web-based resources created to complement 'The avoidance of taints and chemical instabilities' roadshow workshop, ran and completed over the last three years. An article entitled 'Salt removal from wine using electrodialysis' was published in the May issue of the *Australian and New Zealand Grapegrower and Winemaker*. This article detailed independent non-commercial assessment of several electrodialysis trials to decrease salt levels in wine, using technology provided by Memstar Australia Pty Ltd. The aim of these trials was to provide information to winemakers regarding the effectiveness in salt removal, as well as any effects on wine quality, should winemakers require this technology in the future in response to climate change.

The team also offers information and responds to current sector issues through electronic email bulletins (*eBulletin*), with two *eBulletins* released over the year: 'Elemental sulfur residues-potential impact on fermentation and management strategies' addressed potential issues with an early harvest in some regions and 'Management of Botrytis affected fruit' was distributed to address potential issues with mould damage due to late rains in other regions.

An electronic newsletter called 'AWRI *eNews*' was launched this year to provide stakeholders with regular updates every two months of AWRI Research, Development, Extension and Commercial activities and outcomes. Four *eNews* issues were distributed during the period with the Winemaking team using this vehicle to communicate industry trends observed through its Winemaking and Extension Service activities. Ten articles were prepared and included 'Copper watch' which detailed an increase in high copper levels in wines, particular with reference to allowed levels for export; 'Having filtration problems?' highlighted an increase in filtration difficulties with 2008 red wines due to potentially higher polysaccharide levels. 'All about salt' and 'Salt without the hypertension' advised industry of accepted ways of measuring salt in the vineyard through to in juice and wine, and ways to reduce salt levels in the winery. Additionally, the AWAC and Extension roadshows and new additions to the AWRI website were communicated to the wine sector through this medium.

The Industry Support and Extension section of the AWRI website is a primary source of providing winemaking, viticulture, health, regulatory, and technical information to Australian wine producers. A new 'Winemaking Resources' section was added to the winemaking area of the website to enable winemakers to easily navigate and find information. This area contains winemaking calculators, laboratory methods, and a new fermentation area (includes new information on yeast hydration, plotting fermentation graphs, YAN and nutrient information, methods to restart stuck fermentations). New Frequently Asked Questions (FAQs) have been included on the AWRI website on topics such as oxidative pinking, elemental sulfur and Botrytis management.

The Extension section of the website has undergone significant review and now contains detailed information about each roadshow workshop offered by the AWRI, and includes links to relevant information both on the AWRI and cross links to external websites. The 'Avoidance of taints and chemical instabilities' workshop includes links to wine taint and fault sensory thresholds; assessment methods for taints in additives; prevention and wine disposal of tainted or non-saleable wine; as well as the most relevant references that can be requested from the John Fornachon Memorial Library. The new 'A guide to troublefree packaging' workshop provides links to WFA packaging guidelines, *The Code of good manufacturing process* as well as a range of packaging resources available.

The delivery of the elite Advanced Wine Assessment Course (AWAC) continues to be an important career development opportunity for those who wish to strengthen their knowledge in wine show judging and improve their sensory skills. Over 840 participants have completed the program and this year we scheduled the 28th AWAC event. Since the first course in 1992, and in response to feedback from previous participants, the course has been subject to a process of continuous improvement and refinement. The current program is offered in a four day format with more than 40 hours of content. As part of the intensive program; participants have the opportunity to evaluate a diverse range of more than 316 wines under simulated wine show conditions. Lectures are also presented by AWRI staff and also with the participation of 14 leading wine show judges, journalists and winemakers.

Feedback from AWAC graduates suggests that it is very difficult to obtain judging positions at Australia's premier wine show events. In order to fast track opportunities, and to facilitate the development of talented professionals, the top performing participant from each course now has the opportunity to participate as an associate judge at a national wine show level. The Dux of the course, David MacKintosh, Winemaker from Giant Steps has been offered a place as Associate Judge at the next Royal Adelaide Wine Show.

Participants at the Wine Australia/AWRI workshop held in Shanghai

The AWRI and the Institute of Masters of Wine (IMW) concluded a three year cooperation agreement. As part of the arrangement, the AWRI will host the Institute of Masters of Wine each year for the Australasian education program. In November, 52 first, second and third year students attended. Both organisations further agree to co-contribute to the selected delivery of each organisation's education programs.

Our collaboration with Wine Australia continues to strengthen; a number of events were scheduled in important retail markets for Australian wine. The purpose of the AWRI's involvement is to support and underpin the marketing initiatives of Wine Australia, and to advance the importance of research and how this drives innovation within the Australian wine sector. Presentations were based on content adapted from the Advanced Wine Assessment Course and presented either as a one day abridged version of the four day course or a wine flavours, faults and taints evaluation course. In total, six events were scheduled in Europe and Asia. Participation was by invitation only; the list of participants included some of the world's most respected journalists, wine-buyers and educators. The response from the list of 194 attendees has been extraordinary, with considerable press generated in printed publications, media releases and social media sites. There is tremendous scope to continue delivering these events as it highlights the importance of wine education delivered by the AWRI, and the value of take home messages.

The Industry Development and Support group is also responsible for the organisation and delivery of the workshop program for the 14th Australian Wine Industry Technical Conference, currently, 52 workshops have been scheduled offering a total number of 2,170 places. The number of workshops with viticulture content has been expanded and more tastings will be programmed.

WIC Winemaking Services

Staff
Gemma West, Con Simos

WIC Winemaking Services is a collaborative new venture between the AWRI and the University of Adelaide, designed to provide a winemaking service for small- and pilot-scale experimental winemaking with a minimum 20 L or 50 kg lots. Larger sizes can also be accommodated on request and a bottling service is also provided. This capability is designed to service the needs of the research community, winemakers and industry suppliers or those who carry out research trials, test viticultural treatments, undertake process development and evaluate new varieties or products. All of the winemaking is undertaken at Wine Innovation Cluster East: the University of Adelaide's Hickinbotham Roseworthy Wine Science Laboratory. A teaching and winemaking facility, WIC East is purpose-built to accommodate small- and pilot-scale and pilot winemaking.

With the backing of The Australian Wine Research Institute and the University of Adelaide, customers can be completely assured of world's best-practice in winemaking trials.

The winemaking is carried out by Gemma West, a fully qualified winemaker with prior experience in this area.

The venture has been in operation since January 2010 and is totally committed to offering a quality service with a capacity of approximately 300 ferments per year. This is a user-paid service and will be expanded for the vintage 2011.

Transfer of knowledge relating to viticulture

Staff
Dr Sally-Jean Bell, Dr Peter Dry, Marcel Essling

During the year, the viticulture team responded to 342 viticulture-related enquiries. As reported above, the majority (255) were 'agrochemical-related'. The remaining 87 calls related to various general viticulture enquiries. The Senior Viticulturist, Viticulturist and Viticulture Consultant fielded 75%, 18% and 7% of the enquiries respectively.

Other issues of note that were dealt with include strategies for managing heat stressed vines, the effect of water quality on soil health and variety identification. The viticulture team participated in the AWRI Roadshows throughout the year (Appendix 1).

Details of seminars attended during the year are shown in Table 4.

The Senior Viticulturist is facilitating the 'Salty vine and wines' workshop for the 14th Australian Wine Industry Technical Conference. The final program is in place and a presentation entitled 'Salt in grapes and wine' has been prepared. She was invited to give a presentation entitled 'Vine nutritional status can affect wine quality" at the Farmer John's Viticulture Seminar (25/0610) and she also reviewed two papers for the *Journal of the Science of Food and Agriculture* and two papers for the *American Journal of Enology and Viticulture*.

The Viticulturist organised Research to Practice training which took place in all States with the exception of Western Australia. A total of 10 modules, split evenly between the 'Nutrition' and 'IPM' were run including five in New South Wales, two in South Australia and one each in Victoria, Tasmania and Queensland. Fifty-nine Viti-Notes were edited and formatted for the AWRI website covering a range of viticulture topics including grapevine nutrition, pest and disease management, irrigation, spray application and soil management.

The Viticulture Consultant designed and prepared content for Research to Practice training on Alternative varieties, delivered four guest lectures to University of Adelaide viticulture students, worked on the organisation and preparation of 'Emerging varieties from the Mediterranean' workshop for the 14th Australian Wine Industry

Team reports

Technical Conference and contributed to the AWRI's Low Alcohol fact sheet and AWRI report published in the *Australian and New Zealand Wine Industry Journal* and was an invited speaker at the International Wine Law Association Conference (see Appendices). The Viticulture Consultant co-authored four papers in the *Australian Journal of Grape and Wine Research* and a book (Iland, P.G., Gago, P., Caillard, A. and Dry, P.R. [2009] A Taste of the World of Wine [Patrick Iland Wine Promotions Pty Ltd, Adelaide]).

(LtoR) Linda Bevin, Sean Boden, Rae Blair

Communication and Information Services

Staff

Con Simos, Rae Blair, Linda Bevin, Sean Boden, Anne Lord, Ingrid Barratt (returned from maternity leave 3 August 2009), Claire St George (until 6 August 2009), Fiona Taylor (until 29 July 2009) and Susannah Black

The CIS team is a service unit within the AWRI and forms part of the Industry Development and Support group, led by Con Simos. The CIS team is responsible for the strategic sourcing of relevant technical information and, in collaboration with our stakeholders, for its effective delivery to Australian grape and wine producers of all sizes. All of our activities are benchmarked against our team's vision and mission[1], the AWRI's Business Plan[2] and the AWRI's 7 year Research, Development and Extension Plan[3]. The operations of the CIS team also complement and support the knowledge management and communication activities of all of the AWRI staff.

1 See www.awri.com.au/information_services/
2 See www.awri.com.au/about_us/business_plan/
3 See www.awri.com.au/research_and_development/rdec/7_Yr_RDE_Plan_Executive_Summary.pdf

Highlights and activity

Our specific activities include the following:

- Corporate communication and brand management (facilitating effective communication between the AWRI and its stakeholders);
- Information and knowledge management;
- Maintaining the collection held within the John Fornachon Memorial Library;
- Management of the AWRI website, and web-accessible information databases;
- Production of corporate publications, including *Technical Review* and the Annual Report;
- Provision of an editorial service for the staff of the AWRI; and
- Media and VIP visit coordination.

Progress reports on our GWRDC-funded activities are shown below. However, some of the highlights for the 2009/2010 financial year include:

- *Wi*SE (Wine Information for Scientific Endeavours), the AWRI's Intranet and collaboration system, went live at the end of August 2009. The Intranet provides a single access point to a range of information that was previously held in multiple and different locations. From the *Wi*SE homepage, AWRI staff can access news, events, forms, policies, procedures, templates, logos and an image library as well as a library of staff publications held in PDF format.
- Management of a 38% increase in information requests – over 7,000 enquiries were responded to during the year.
- Eleven *eBulletins* were issued.
- A new communication tool, the AWRI's *eNews*, an electronic newsletter, was launched in February 2010, and is issued bi-monthly.
- Thirteen new Fact Sheets were uploaded to the AWRI website.
- Increased usage and improved management of Information Resources: an extremely strong year was recorded in delivering information solutions to customers in-house and within the grape and wine sector. In particular, a 65% increase was recorded for documents forwarded to customers.
- A number of new resources were added to the AWRI website this year, including an extensive series of pages on viticulture pest and disease management, environment and sustainability tools, improved winemaking resources and streamlined consumer recruitment tools.

Provision and development of mechanisms for the efficient transfer of knowledge and technical information to the Australian grape and wine sector

Staff

Rae Blair, Sean Boden

The AWRI utilises several strategic and effective mechanisms to disseminate knowledge and information to Australian grape and wine producers. Reported above are the physical extension activities – the body contact sport – undertaken by the other members of the Industry Development and Support group. Below are details of the less direct, or personal, extension/communication mechanisms, but nonetheless deliver information to the vast majority of our stakeholders.

Annual report

For the past 55 years, the AWRI has produced a printed annual report such as this one, as its formal report to Australian winemakers and grapegrowers. Since 1999, the annual reports have been made available also for downloading on the AWRI's website. In an endeavour to improve the circulation across Australia of the AWRI's annual activities, we also publish a four-page supplement in the November issue of the *Australian and New Zealand Grapegrower and Winemaker*, and we approach all the major State-based winemaking bodies and offer an annual presentation to their members. This formal

activity complements the vast range of presentations and publications undertaken by AWRI staff members throughout the year (Appendix 1).

AWRI website

We recognise that the effectiveness and true value of the AWRI website, as an information resource, comes if the information is relevant, easy to find and current. An increase in our in-house capability to produce new and exciting ways to engage our stakeholders online has seen a number of new initiatives take place over the last year. This has included an extensive array of viticulture information (including detailed notes on pests and diseases in the vineyard; information sheets, online tools and databases of specialised information regarding environmental issues, including climate change, process efficiencies and sustainability) and an overhauled and significantly enhanced series of winemaking resources.

Following the changes in the website restructure that took place last financial year, the website has seen a decrease (-9.25%) in usage over the last 12 months (Table 5 and Figure 23), which can largely be attributed to changes in indexing. Despite the decrease in visitors, there have been a number of improvements: the number of pages accessed per visit is up 13%, and the average amount of time spent browsing the site is up 18.5%. This shows that information consumption per capita has actually increased, and visitors are browsing longer per visit.

Table 5. Website statistics 1 July to 30 June

	2009	2010	% change
Website page-views comparison	348,608	316,358	-9.25%

Technical Review

The AWRI's *Technical Review* continued to be produced and distributed throughout the year. Mailed out in hard copy, and electronically searchable via the AWRI's website, *Technical Review* continues to provide a valuable summary of current literature relevant to grape and wine production. The October issue further provides comprehensive lists of yeast strains; bacterial cultures; and pectic and lysozyme enzyme preparations available for winemaking.

In the financial year of 2009/2010, more than 20,000 copies of *Technical Review* were distributed to Australian grapegrowers and winemakers who pay the *Grape Research Levy* or *Winegrapes Levy* and subscribers in Australia and overseas. Over 650 articles featured in *Technical* Review were requested and forwarded to readers (53% increase over last year).

Editorial services

The Australian Wine Research Institute contributes a regular column in the *Australia and New Zealand Wine Industry Journal* and continues to publish in the *Australian and New Zealand Grapegrower and Winemaker* and Australia's *WBM* amongst other Australian and international industry journals. All papers authored by the AWRI staff, to be published in non-peer reviewed publications, are edited by the Communication Manager (details of the articles published are in Appendix 5). The Communication Manager also reviews all material to be uploaded to the AWRI website.

Teams across the AWRI continued the development of Fact Sheets relevant to their area of expertise. The Fact Sheets are presented in an easy to understand, single topic, format and are all downloadable from the AWRI website. The Communication Manager is responsible for editing these Fact Sheets prior to distribution and uploading to the AWRI website and. Thirteen Fact Sheets were prepared during 2009/2010 and are listed in Table 6.

Provision of scientific, technical and regulatory information

Staff

Linda Bevin, Sean Boden, Anne Lord, Ingrid Barratt (returned from maternity leave 3 August 2009), Claire St George (until 6 August 2009), Fiona Taylor (until 29 July 2009)

The John Fornachon Memorial Library

The John Fornachon Memorial Library holds the largest collection of grape and wine technical literature in the Southern Hemisphere, covering winemaking, viticulture, wine microbiology, flavour chemistry, phenolics, food chemistry, wine and health, wine and the environment, and more. The collection includes books, journals, article reprints, conference proceedings, reports, theses, standards and legislations, as well as a reference collection of foreign dictionaries and atlases. Over the last 12 months, the Library has begun adding DVDs and e-books to the collection to ensure the collection meets the requirements of its stakeholders.

The AWRI has an ever-growing knowledge base, and technology is providing opportunities for the John Fornachon Memorial Library to evolve beyond the traditional concept of libraries and focus on the expansion of electronic information access and delivery. While printed material still forms a solid core of the Library's offerings,

Table 6. Fact Sheets prepared and uploaded to the AWRI website during 2009/2010

Fact Sheet title	Group
Agrochemicals for vine mites in WA	Industry Development and Support
AWRI's Tannin Portal	Industry Applications
Understanding results from the tannin portal	Industry Applications
AWRI's OTR method	Commercial Services
Managing *Botrytis* infected fruit	Industry Development and Support
Reducing alcohol levels in wine	Research
BevScan: general application	Industry Applications
BevScan: wine oxidation	Industry Applications
Energy audit	Industry Applications
Renewable energy	Industry Applications
Compressed air	Industry Applications
Heat transfer	Industry Applications
AWRI – quick facts	Communications

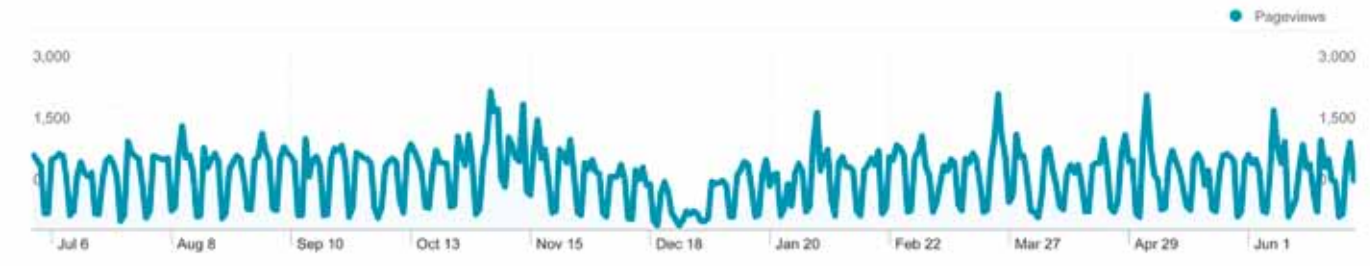


Figure 23. Website pageviews for 1 July 2009 – 30 June 2010

the proliferation of digital content and the highly accessible nature of electronic documents are such that most requests are ultimately fulfilled via digital document delivery via e-mail, regardless of whether the initial query was received in person, over the phone or via the AWRI website.

As part of an ongoing commitment to ensure its service and holdings remain accessible and in line with technological trends, the John Fornachon Memorial Library has been actively working to emphasise electronic document delivery as a fast and cost-effective method of information dissemination to the Australian grape and wine sector. The past 12 months has seen the library upgrading its equipment to improve the speed and quality of digitised materials in fulfilling requests for critical information to our stakeholders. The net result has seen the library team increase its information services delivery to the grape and wine sector by an impressive 38% over the course of the financial year (see Table 8). Looking forward, the team is excited to continue investigating streamlined and innovative ways to increase the availability of information and research results and will be implementing more proactive online solutions in the next 12 months that should prove beneficial for its constituents.

Online information databases

Three information databases, available via the AWRI website, can be accessed by all grape and wine producers who pay the *Grape Research Levy* or *Winegrapes Levy*. The databases are a valuable information resource comprising records of books, journal articles, conference proceedings, reports, standards and legislation held in the AWRI collection, and users of the databases can also request items online.

There continues to be strong demand for information access via the web, either directly via the online information databases, through the reference lists on common topics (such as smoke taint) or by getting in touch with the Library over email, telephone or in person. The AWRI catalogue has undergone significant maintenance over the last 12 months, as indicated by the exceptionally high rate of records maintenance (see Table 7). This has been done as part of the ongoing modernisation of the library catalogue in order to enact a framework to speed up document delivery and availability of information. Figure 24 provides a summary of database usage during 2009/2010.

John Fornachon Memorial Library catalogue databases

The Library holds over 65,000 records of books, conference proceedings, theses and scientific, technical and medical reprint articles. They are indexed in the Library's database catalogue which is accessible via the John Fornachon Memorial Library. Details of the Library's journal holdings including newsletters, statistics and annual reports are held in the *Journals* database. A summary of the size of the Library's catalogue and information databases is given in Table 7.

Specialised information services

While the usage of the AWRI's *Industry* online information database is increasing and the database is available free of charge to all Australian grapegrowers and winemakers who pay the *Grape Research Levy* or *Winegrapes Levy*, customers are continuing to request the Library to conduct online searches using commercial databases on a fee-for-service basis.

Table 7. Description and number of records of online information databases and library catalogues

Web accessible information databases	
Industry (with searchable abstracts)	61,833
Environment	2,218
AWRI Online Image Collection	2,338
Library catalogues databases	
AWRI_database (library catalogue)	65,197
Journals (journals, theses, statistics and annual reports)	491
REGS: European Community wine legislation	412
New items and maintenance to the information databases	
New monographs	321
Theses	0
Record maintenance	53,999
Reprint Collection to date (see below for details)	29,057
- Reprints	20,094
- AWRI publications	1,196
- Articles indexed via Technical Review	7,767

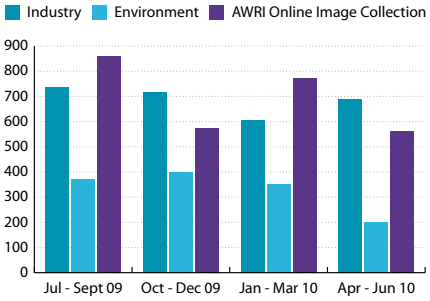


Figure 24. Summary of database usage during 2009/2010

Document delivery services

'Document delivery' services entails the supply of journal articles, books, DVDs or other library items to customers upon request via post, fax or electronically via email in PDF format where applicable. This also includes sourcing items held by other Australian and overseas libraries if the requested content is not available in-house. The ability to order items online means that the majority of document requests are able to be completed within three days.

The Library has recorded an impressive year of activity. This includes a 38% overall increase in information requests received and completed and a 65% increase in documents forwarded to requestors. Both of these display continual improvements over past years, and demonstrate a very positive trend for continued utilisation of the Library's services (Table 8).

Library collection

A total of 321 monographs were added to the collection in the financial year of 2009/2010. The Library continues to subscribe to 72 journals and receives over 70 annual reports, newsletters, journals through exchange and donation. The collection also holds over 29,000 reprints that consist of AWRI staff publications, articles featured in *Technical Review* and articles obtained from other suppliers (Table 7).

Donations to the Library collection

The AWRI wishes to thank all individuals and companies who contribute to the collection through donations or exchange agreements. The support of the following persons and organisations who have donated books, journals or photographic material is acknowledged:

Australian Dried Fruits Corporation, Australian Wine and Brandy Corporation, Australian Wine and Brandy Producers' Association, Commonwealth Scientific and Industrial Research Organisation, Leigh Francis, Linda Halse, Northwest A & F University (China), Sakkie Pretorius, and the Winemakers' Federation of Australia Incorporated.

Improvement of knowledge management and stakeholder communication

Staff

Rae Blair, Linda Bevin

In its 55 years of operation, the AWRI has generated (and continues to generate) substantial amounts of unique information on the technical aspects of wine production. A key aim of our activities is to ensure our existing knowledge becomes a catalyst to more freely create new knowledge. This can only be achieved if the information and knowledge is managed to become more useful and 'user friendly' not only to Australian grape and wine producers, but also for the staff of the AWRI. We continue to investigate and utilise new technology to fulfill our objectives. Our project activities complement the other activities of the CIS team (as reported above) and the communication aims of all staff members at the AWRI. Our aim is to ensure greater penetration of information to our stakeholders; whilst supporting the positive perception of Brand Australia to the ultimate benefit of the Australian grape and wine sector.

Information and knowledge management

W*i*SE (Wine Information for Scientific Endeavours), the AWRI's intranet and collaboration system, went live at the end of August 2009. The intranet provided a single access point to a range of information that was previously held in multiple and different locations. From the W*i*SE homepage, staff at the AWRI can access news, events, forms, policies, procedures, templates, logo and image library as well as a library of staff publications held in PDF format.

Over a three-month period from November to January, W*i*SE introduction training was delivered to staff enabling them to use the collaboration functionality in team sites and project sites. This was followed by the development and implementation of approval workflows for board reports, AWRI fact sheets, leave application and Personal Development Plans. Key benefits with the introduction of the workflow tool include the time savings for staff as processes are streamlined through the use of automation and a 'greener' AWRI as we are able to reduce the use of paper.

Improved communication with stakeholders

The AWRI continued its relentless pursuit of connecting with stakeholders throughout the year. Specific evidence of this can be found under the Appendices, which detail the number of Roadshow/workshop presentations and other presentations given, and papers published, by staff at the AWRI. In this project, we collaborate across the entire AWRI staff to facilitate the effective delivery of information to stakeholders via various mechanisms. Electronic delivery of information to stakeholders' desktops has continued to be a priority. This year, we adopted the use of a proprietary software program to more efficiently manage our email bulletin address lists, and to maximise delivery of bulk emails to 'inboxes' and minimising those ending up in 'Junk'. The program has also delivered time savings for our staff, as the program allows our stakeholders to automatically register to, or unsubscribe from, the AWRI's email list. With a continued emphasis on agrochemical updates, eleven email bulletins were delivered during the year and are shown in Table 9.

The AWRI launched its electronic newsletter in 2010, as an initiative from the AWRI's internal Leadership Program. This new external communication tool from the AWRI is called the AWRI's *eNews*. Initially championed by Geoff Cowey (Industry Development and Support) and David Jeffery (Research), as part of their Leadership Program participation, the Communication Manager is now responsible for the production and distribution of *eNews*. *eNews* gives a quick overview of current AWRI projects and other information deemed of interest to our

Table 9. *eBulletins* issued during 2009/2010

Date	*eBulletin*	Authored by	Delivered to number of addresses
16 Sep 09	Agrochemical update	S.J. Bell	3,155
13 Nov 09	The AWRI website: now more information, features and a facelift	R.J. Blair, S. Boden	3,155
26 Nov 09	The AWRI's Annual Report now available	R.J. Blair	3,155
20 Jan 10	Phosphorous acid addition advice to industry / Natamycin analysis	S. Guy, C.A. Simos, C.S. Stockley, R.J. Blair, R.L. Taylor	3,155
4 Feb 10	New service from the AWRI gives greater control over wine quality to winemakers	R.J. Blair, V. O'Brien	3,155
24 Feb 10	Elemental sulfur residues – potential impact on fermentation and what you can do	M. Essling, C.A. Simos	3,155
23 Mar 10	Managing *Botrytis* infected fruit	M.G. Holdstock	2,762
29 Mar 10	Agrochemical update	S.J. Bell	2,720
27 Apr 10	Celebrating 55 years	R.J. Blair	2,703
10 Jun 10	Agrochemical update	M. Essling	2,697
29 Jun 10	Agrochemical update	M. Essling	2,629

Table 8. Summary of information requests during 2009/2010

	Wine industry		Staff		Other[5]		Total		% Change
	2010	2009	2010	2009	2010	2009	2010	2009	2009
Information requests[1]	1575	1212	1485	930	757	633	3817	2775	38%
Technical Review requests[2]							179	124	44%
Technical Review articles forwarded[3]							658	429	53%
Articles forwarded[4]							1935	1171	65%
Number of AWRI publications forwarded[5]							552	519	6%

1. Includes overall article, book and general requests, copyright advice, literature searches and website account enquiries.
2. Number of requests received for articles published in *Technical Review*.
3. Number of articles forwarded from *Technical Review* (usually more than one article is requested).
4. Number of articles forwarded from the library collection, excluding staff publications.
5. Requests from students, Government agencies, private companies and overseas customers for publications authored by AWRI staff.

(LtoR) Randell Taylor, Tim Reilly, Leanne Craddock

stakeholders. It is planned that *eNews* will be distributed during the alternative months to the delivery of *Technical Review*: that is, during the first week of March, May, July, September, November and sometime during January. This initiative effectively doubles our communication with stakeholders and means information is received by them from the AWRI at least monthly: either in the form of *Technical Review*, *eNews* or through our *eBulletins*. Four *eNews* were distributed since the start of 2010 (Table 10). The software program we use to distribute *eNews* provides us with reports with some information as to what recipients do with the *eNews* when they receive it. The report records how many people open the email; the number of times it is forwarded; and the 'click rate', e.g. what links the recipient clicks on within the email. This type of information supports the tailoring of content and frequency of *eNews* to more closely meet the needs of our stakeholders.

Media liaison

The AWRI is often approached for comment on wine technical matters from national and international media. We take this opportunity to ensure accurate information is published about wine made in Australia and to generate further communication opportunities with our stakeholders. Many requests from the media were handled during the year, and specific details can be found in Appendix 4. Media releases prepared and distributed during the year are shown in Table 11.

Special seven paper series

The Managing Director and the Communication Manager prepared seven papers called the 'Beyond' Series, for publication as shown inTable 12. The last six papers focused on leadership and innovation principles in the context of the Australian wine industry and its current environment. These papers were published in six consecutive issues of *WBM,* with the first paper published in April to coincide with the AWRI's 55th anniversary. The aim of the series is to give information about how the AWRI is responding to the industry's economic and environmental challenges, and to put it into a thought-leadership context.

Table 12. The 'Beyond' Series of papers published

Title	Publication
Beyond 2010	January 2010 *Aust. N.Z. Wine Industry Journal*
Beyond the buzz	April 2010 *WBM*
Beyond competition	May 2010 *WBM*
Beyond change	June 2010 *WBM*
Beyond collaboration	To be published July 2010 *WBM*
Beyond value	To be published August 2010 *WBM*
Beyond leadership	To be published September 2010 *WBM*

Commercial Services

Staff:

Vincent O'Brien, Leanne Craddock, Randell Taylor, Warren Roget, Simon Nordestgaard, Karl Forsyth, Neil Scrimgeour, Simon Odell, Oliver Lovat (concluded 30 November 2009), Jean Macintyre (commenced 1 August 2009), Teegan Schurgott (concluded 25 September 2009), Alana Williams, Andrea Francis (concluded 30 April 2010), Melissa Nutt (commenced 1 October 2009), David Boehm, Heather Tosen, Slavko Bekavac, Yvonne Staeffler (concluded 2 April 2010), Daniel Tynan, Pamela Stepancich, Timothy Reilly, Carlo Congiusta

The AWRI Commercial Services financial performance was strong in the 2009/2010 financial year with an increase in our turnover of over 21% compared to 2008/2009 figures. This growth has enabled us to assist the Australian wine industry not only through direct provision of technical support and services but also through injecting our surpluses into the AWRI research programs. We believe this success was underpinned through our efforts to build not only cost competitive high quality services that give our customers a competitive edge, but also a clear value proposition for these tools.

Our goal is to provide technically robust services to help Australian wineries make the correct decisions and stay competitive in increasingly challenging economic and environmental conditions. Our expanded portfolio of capabilities now includes the following:

- Analytical and Trace laboratories.
- Packaging solutions.
- Sustainable production.
- Spectral technologies.
- Consumer preference evaluations.
- Sensory analysis.
- Biotechnology solutions.
- Winemaking operations improvements.

Table 10. *eNews* produced and distributed during 2010

Date	No. of email addresses
2 Feb 10	3,156
4 Mar 10	2,760
3 May 10	2,741
1 Jul 10	2,700

Table 11. Media releases prepared and distributed 2009/2010

Announcement	Date distributed	Author
The AWRI supports continued professional development of MWs	2/7/09	R.J. Blair and C.A. Simos
Dux of AWAC announced	21/8/09	R.J. Blair
The AWRI announces new Chairman	7/10/09	I.S. Pretorius
New service from the AWRI gives greater control over wine quality to winemakers	4/2/10	R.J. Blair
AWRI announces new Chair of Board	23/2/10	R.J. Blair

A brief overview of our highlights and some of our new capabilities are outlined below:

» The launch of our new marketing material.

» Technical achievements including:

- Improving winery refrigeration efficiency.
- Oxygen management findings.
- Aroma capture technology.

» Capability developments including:

- Laboratory turn around time improvements.
- A local sample pick-up service.
- Oxygen management measurement technologies.
- Sustainable production expertise.
- Winemaking operations improvement group.

Marketing material

Over the past three years, we have successfully implemented our strategy to capitalise on the AWRI's in-house technical expertise, through expanding the scope of our service offerings from the provision of just analytical data to the provision of information. Associated with this change in scope, the Commercial Services name was changed from the then 'Analytical Services', to more accurately reflect the range of services available. Our new logo was also designed to more distinctly brand the fee-for-service section from the AWRI's levy-funded functions.

Our new marketing approach (see example in Figure 25), which leverages the CSI theme, is designed to emphasise and promote our modern cutting edge image; scientific rigour and technically robust approach; and reliable, credible and trustworthy services. A feature also of the campaign is that we are personable, approachable and fun to work with; that we are backed by the AWRI's technical expertise; and the approach is strategically designed to cut through to the market place and be noticed.

Technical achievements

Technical achievements includes:

» improving winery refrigeration efficiency;

» oxygen management; and

» aroma capture technology.

Improving winery refrigeration efficiency

Electricity is responsible for well over 50% of most wineries' Corporate Greenhouse Gas emissions and typically well over 50% of their electricity bill. Improving refrigeration efficiency, therefore, provides many wineries with a significant opportunity to improve their environmental credentials and save money at the same time.

The efficiency of a refrigeration system is often described using the term Coefficient of Performance (COP), which is a ratio of the amount of effective cooling provided by the refrigeration plant, QL to the amount of energy supplied to the system Win. The higher the COP, the more efficient the system.

Figure 25. Part of the AWRI Commercial Services' marketing campaign for 2010

Equation 1

$$COP = \frac{Q_L}{W_{in}} = \frac{T_L}{T_H - T_L}$$

Many wineries use a reverse-cycle refrigeration system with an air cooler. For this system, the maximum COP can be related to a function of T_H, equitable to the ambient temperature and T_L proportional to the cold brine temperature through applying the first law of thermodynamics. Equation 1 shows that warmer evaporator temperatures should lead to an improvement in refrigeration performance.

This theory was put to the test with a trial considering three separate brine temperatures, which represent three different evaporator temperatures. The trial results shown in Figure 26 clearly show significant improvements in refrigeration efficiency can be achieved (approximately 20%), simply by increasing brine temperatures by 4°C.

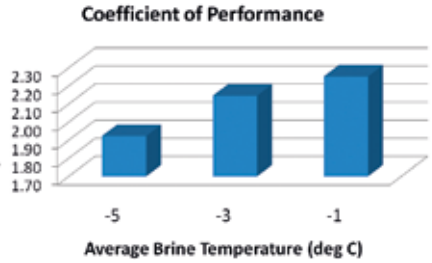


Figure 26: Effect of brine temperature on the Coefficient of Performance

Insulation plays a vital role in conserving refrigeration within a winery. Consider the following theoretical calculations, where a 20 kL tank, holding wine at -5°C is observed for a typical cold stabilisation period of 200 h. For a tank insulated with polystyrene, the average heat load on the tank will be 7.0W per square meter. To maintain the temperature for 200 h this would cost about $3.50.

For a tank insulated with fiberglass, the average heat load on the tank will be 9.0W per square meter. To maintain the temperature for 200 h this would cost about $4.80.

For an un-insulated tank, the average heat load on the tank will be 85W per square meter. This would equate to approximately $46.00 in electrical costs to maintain the temperature.

Wineries conduct a significant number of cold stabilisation treatments each vintage, these costs are typical for each and every tank processed.

Oxygen management

Measuring only dissolved oxygen at bottling for quality assurance doesn't give you the full story. The AWRI Commercial Services bottling line benchmarking services across Australian and New Zealand facilities have shown that over 60% of the oxygen in the bottle is in the headspace. If you are only monitoring the dissolved oxygen (DO), then you are overlooking the majority of the oxygen that is getting into your wines at bottling. The oxygen in the headspace as well as the DO (the total package oxygen [TPO]), reacts with your wine. The TPO value at bottling has been shown to have a significant impact on the shelf-life of the wine post-bottling and it can also have an impact on the wine sensory properties. An example of the impact of best practice and worst practice TPO management at bottling on wine shelf life is shown in Figure 27.

The wine bottled with an initial free SO_2 level of 27 mg/L and industry worst-practice oxygen management at bottling, a TPO of 5 mg/L, appears to be approaching the end of its shelf-life after only four months in the bottle!

The AWRI Commercial Services now offer two ways to quantify total package oxygen at bottling:

» our benchmarking services using the Nomasense oxyluminesence technology; and

» using the AWRI TPO calculator.

Oxygen does not completely dissolve in wine even after vigorous shaking – a significant residual amount remains in the headspace. Measuring TPO at bottling is critical, however, many wineries only have equipment that enables them to measure the dissolved oxygen phase. To assist these wineries to effectively manage their bottling operations using their existing equipment, the AWRI Commercial Services has developed a method to approximate the TPO using our TPO calculator.

The rate of oxygen diffusion through a closure subsequent to bottling has a dramatic impact on the wine style developed in the bottle and the ultimate shelf life of the product as highlighted by our 2007 White wine closure trials shown in Figure 28. The oxygen transmission rate (OTR) is a key closure performance parameter that can now be accurately quantified non-destructively and *in situ* for all packaging technologies using a new method developed by the AWRI Commercial Services. The method involves placing the packaged wine inside a sealed container, as shown in Figure 29, and calculating the OTR from the rate of decline in oxygen concentration outside of the bottle. This method is currently being used by wineries to select between packaging technologies to give desired flavour style evolution and shelf life.

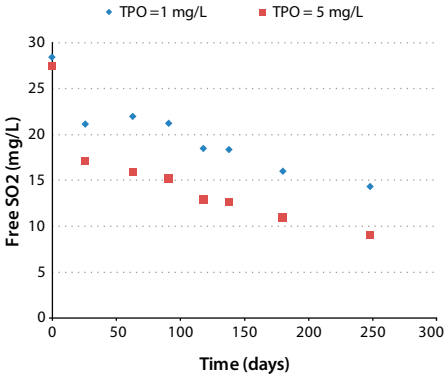


Figure 27. Impact of TPO on wine shelf-life, oxidised characters typically develop in white wines when the free SO_2 values drop to approximately 10 mg/L

Aroma capture technology

From the start through to the end of a ferment, up to 25% of aroma compounds critical to the aroma profile of the product are swept away by ferment off-gas. The AWRI Commercial Services has designed, commissioned and is currently testing the financial viability of a technology to capture aroma compounds from fermentation off-gas as part of a commercial project. The project findings are only available to participating wineries, however, currently the technology is showing significant promise for securing value from an existing waste stream.

Capability developments

The AWRI Commercial Services have developed several novel analytical and technical capabilities in an effort to support wineries to build technical knowledge about their products and improve the efficiency of their operations.

Streamlining our laboratory operations has continued using lean manufacturing principles. This has enabled us to dramatically reduce our analysis turn-around times for standard routine analysis to same day reporting of results while still maintaining our quality assurance focus. Export certification requirements for VI1 and AWBC continuing approval are all done on the same day, and tasting samples are forwarded free of charge onto the AWBC's next available session on the following day. In addition, our invoicing processes have also been improved to weekly cycles.

We have successfully commercialised several new analytical capabilities including:

» A new streamlined and cost-effective suite of agrochemical residue compounds registered for use in the Australian wine industry all measured using our triple quad LCMS.

» A method for measuring Natamycin levels in wine.

» Web portal that enables rapid quantification of tannin levels with a basic UV-VIS spectrophotometer developed by AWRI's Industry Applications group.

» A sustainable production capability with expertise in carbon foot printing led by Karl Forsyth.

» An expertise in process streamlining from Neil Scrimgeour who holds a 'black belt' in Lean Manufacturing and Six Sigma.

The AWRI Commercial Services has set up a Winery Operations Improvement Group with the goal of helping the Australian wine industry to capitalise on advanced manufacturing approaches commonly used in other industry sectors. The focus group comprises winemakers and operations managers from wineries of differing sizes and it will explore the opportunities for advancement of the wine industry through the identification of:

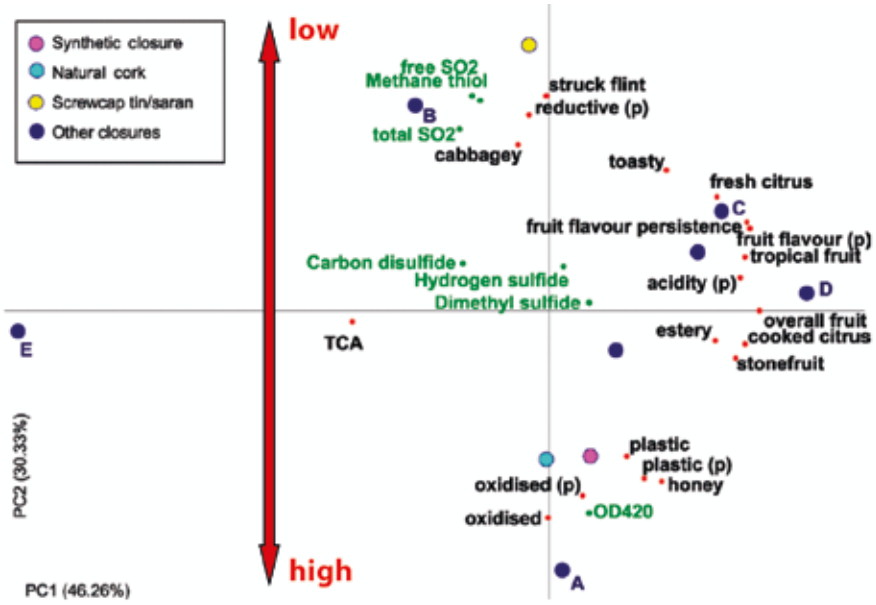


Figure 28. A PCA plot from the AWRI Commercial Services 2007 White Wine Closure Trial showing the impact of closure OTR on wine style evolution

(LtoR) Jean Macintyre, Warren Roget, Kate Lattey (Orlando Wines). Location: Orlando Wines, Rowland Flat

» the most common areas of opportunity across the winemaking process;

» the technologies that could provide access to these opportunities; and

» funding opportunities or frameworks to enable cost-effective proof of performance evaluations.

Critical to the sustainability of Australian wineries is the adoption of smart technologies which facilitate production of high quality wines, as well as the minimisation of environmental impact and production costs. There are several barriers that are currently making this difficult to achieve including:

» Advanced manufacturing technological opportunities designed to support Australian winemaking philosophies and practices have not been clearly identified.

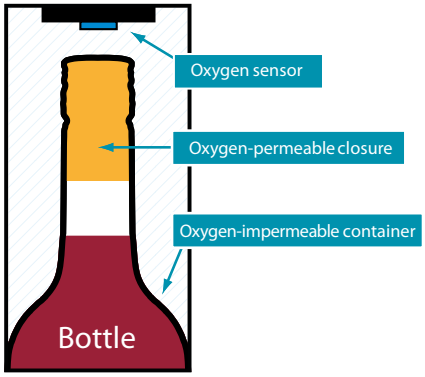


Figure 29. Pictorial representation of the AWRI wet OTR method. OTR is calculated from the rate of oxygen depletion in the reservoir of air external to the closure

» Australian wineries can be misled by sales campaigns and dubious proof of performance assessments leading to significant suspicion and confusion about the merits of available advanced manufacturing technologies.

» Many suppliers of advanced manufacturing technologies reside overseas and the technologies they produce service Old World style winemaking practices and not the more innovative approaches used by the Australian wine industry. This creates a disconnect between technical interests in Australia and available manufacturing technologies.

Participants from our first preliminary forum were winemakers and operations managers from 10 different wineries. Participants were very supportive of the concept and selected the following themes of interest for subsequent meetings:

» Alternative cold stabilisation techniques.

» Ullage management technologies.

» Alternative maturation technologies.

» Refrigeration technology.

During each quarter of the year, a forum will be devoted to each of these themes to establish the key performance criterion requirements; evaluate the technologies available; and review options available to facilitate the provision of technologies that meet the industry's needs.

Corporate Services

Staff

Hans Muhlack, Catherine Borneman, Mark Braybrook, Michelle Carter, Jeff Eglinton, Anne Haworth, Pauline Jorgensen, Linda Halse, Jan O'Donnell, Deborah Thornton-Wakeford, Jeanette Tooley

The Corporate Services Group at the AWRI consists of a team of specialised and dedicated people who live the values of the organisation and whose prime focus is to provide high levels of service to both internal and external clients. The AWRI's strong scientific credentials and the Australian wine sector's international reputation for innovation are important factors to attract and retain people who have particularly unique skill sets. The Group Manager, also the AWRI Company Secretary, has more than 30 years experience working in the wine sector. His knowledge and experience in financial management and industry background are contributing factors to achieving good Corporate Governance and financial strength. His role is supported by the Accountant whose chartered accountancy qualifications and prior commercial experience ensures the AWRI's accounts and financial reports are prepared with professional rigour and comply with statutory requirements.

Our IT Manager's prior experience as a microbiologist is invaluable in understanding the scientific landscape that our IT facilities need to support and in foreseeing the type and range of systems that are required to enable the success of our RDE&C model.

We have an HR Manager with an international and varied background whose prior successes at the AWRI have been recognised by The Australian Human Resources Institute. In this past year, she has contributed a book chapter in a publication due for international release on 'Employer Branding' in which the AWRI Human Resources story is cited as a case study.

The AWRI Operations Manager has used his many and varied skills to devise engineering solutions for a variety of applications to support all Groups within AWRI including the coordination and liaison with the University of Adelaide in relation to ongoing management and maintenance of the WIC Central Building.

The administrative and support roles ranging from Reception through to the Accounts Receivable and Payable continue to strive for a high level of client satisfaction.

Financial Statements - Directors' report

The Directors present their financial statements for the year ended 30 June 2010.

Review of Operations

The new WIC Central building now provides AWRI staff with world-class facilities, to assist in underpinning world-class research for the benefit of the Australian wine industry.

This financial year is the fourth year of the 7-year GWRDC Investment Agreement. In accordance with the Investment Agreement the 'Approved Funding' was reduced and remains at this level for the remaining three years. The AWRI was extremely fortunate that the GWRDC approved an indexed amount of Supplementary Funding during the year, albeit that the amount was less than the reduction in Approved Funding. On a more positive note, the AWRI was awarded two GWRDC projects outside the Investment Agreement: one, an industry collaborative project examining phenolics in white wine, and the second, a project examining energy efficiencies in relation to winery refrigeration.

Given major changes in the Federal industrial relations landscape, the renegotiation of the AWRI's Workplace Agreement was somewhat more complex than when the previous agreement was negotiated three years earlier. However, the '2009 AWRI Internal Employment Standards Agreement' was endorsed by the great majority of staff.

The integration of the business activities of Provisor Pty Ltd early in 2010 resulted in the AWRI taking on the provision of small-lot winemaking in conjunction with the University of Adelaide (WIC Winemaking Services). The AWRI has employed two ex-Provisor staff with specific expertise in life-cycle analyses, carbon reduction strategies and energy optimisation, which augments existing capabilities in engineering and project management consulting capacity. These specialist staff complement and strengthen the AWRI's RDE&C business model by increasing its capacity to offer services and project management support to help overcome the challenges of environmental sustainability faced by the Australian wine industry.

Last year we reported on the work undertaken to enhance Corporate Governance. Initiatives undertaken included modernising the Constitution, strengthening the composition of the Board, enhancing accountability and transparency in relation to the election of levy payer nominated directors and completing the transition to a skills-based Board. This year, the Board has adopted a formal Corporate Governance Policy, a Board Charter and a Code of Conduct which together give substantive conformance with *AS 8000* 'Good governance principles'. Further work is being undertaken to achieve similar conformance with *AS 8003* 'Corporate social responsibility'. This will be, in part, the AWRI's tangible support of the GWRDC's public benefit objectives of providing social, environmental and economic benefits to regional and rural Australia. These objectives will be further supported by the AWRI planning to establish a 'Riverina' node in Griffith, New South Wales, in collaboration with the National Wine and Grape Industry Centre and Charles Sturt University. This node will have a focus on environmental sustainability and process improvement.

A major review of the AWRI's 10 year Business Plan 'Towards 2015' was commenced in the first half of 2010. This strategic process evaluated the AWRI's competitive and political environment and has given the impetus to the formulation of several new strategic initiatives. These initiatives are shaped to enhance the value and relevance of the AWRI's activities for the Australian wine industry.

It is pleasing to report the launching this year of some exciting outcomes from the AWRI's 'Development' activities under the auspices of the AWRI's Industry Applications and Commercial Services Groups, that have the potential to benefit the great majority of levy payers. After many years of tannin research, the collection, calibration and validation of data has been 'packaged' via some sophisticated software as the AWRI's 'Tannin Portal'. This will enable winemakers to submit their own tannin data and have their wine compared to the AWRI's database by variety, region, vintage, etc. The second major achievement has seen the AWRI's analytical and sensory expertise utilised to develop the 'Pinot G Style Spectrum' which will give winemakers and marketers the ability to submit their Pinot Gris or Pinot Grigio wines for analysis and ranking in a spectrum ranging from 'crisp' to 'luscious'. Thirdly, the AWRI spectral expertise has been utilised to produce a relatively low-cost scientific instrument to measure important wine variables in bottle. The calibration of the instrument has been the main area of the AWRI's involvement and carries the AWRI's endorsement for that aspect of its operation. The AWRI will receive a modest royalty on all units sold.

An important factor in the AWRI being able to have reported some ground breaking outcomes in smoke taint research has been the close collaboration between the AWRI's Research and Industry Development and Support (IDS) Groups. Importantly, this work has also complemented work being done by other research agencies to achieve the best results for industry as a whole.

Another major outcome for the Research Group this year was the identification of four more genetic codes of wine yeast. The IDS Group also broke new ground by scheduling a number of themed tasting events based on the Advanced Wine Assessment Courses in Hong Kong, Shanghai , London and Dublin. The IDS Group has also successfully revitalised a number of 'Research to Practice' modules previously undertaken under the auspices of the former CRC for Viticulture. A number of modules has been presented and well received with more revised modules in the pipeline.

The continued growth of the AWRI's Commercial Services business is particularly pleasing. The major growth has been in the project management area with a focus on specialist engineering and packaging solutions. The traditional analytical service laboratories have also worked hard to gain increased business and have succeeded in improving revenue in a difficult business environment.

Results of Operations

Total Comprehensive Income has substantially reduced from last year mainly as a result of a large reduction in capital income and the absence of once-off gains from the disposal of assets. The other main factors contributing to the reduction in the operating surplus are discussed in detail below.

Revenue is made up of direct funding, commercially derived income and prior year's unspent GWRDC funding, approved for use this year. Other Capital Funding is largely derived from unspent funds and is the revenue component with the greatest reduction in funding in comparison to last year. Project funding overall has increased slightly this year, however, there has been no unspent funds arising from GWRDC Investment Agreement projects. There has been positive growth in revenue generated by the Commercial Services Group. This growth has been achieved in an increasingly competitive environment and augurs well for the future.

Staff expansion in the Commercial Services Group and an increase in leave provisions accounted for the majority of the increase in staff costs. A substantial increase in the use of liquid nitrogen was the main contributor to greater consumables cost. This cost will moderate in future with new liquid nitrogen infrastructure installed in the latter half of the year. The other main components that contributed to the increase in 'Expenses from operating activities' were an increased level of analyses, depreciation expense and extra costs associated with the Commercial Services Group's increased scale of operations. The modest margins that the Commercial Services Group had to work with given tough industry conditions also reduced profitability.

The level of Operating Surplus has to be seen in the context of an organisation whose main operational activities are not profit driven.

Significant changes in state of affairs

There are no significant changes in the state of affairs of the AWRI.

(LtoR) Catherine Borneman and Roxanne Portolesi

PRINCIPAL ACTIVITIES

The principal activities of the AWRI have not changed significantly and are best described as:

» *Research* activities which strive for scientific excellence and industry relevance,

» *Development* activities which seek to bridge the gap between scientific discovery and value adding technology or processes,

» *Extension* and *Education* activities that seek to disseminate research and development outcomes and provide training to facilitate rapid uptake by the viticultural and winemaking sectors. In addition, problem solving services and an on-line search capacity across a range of technical websites are also provided, and

» *Commercial* services aimed at providing competitive specific and/or tailored solutions for individual entities across many areas within the industry which leverage from the other key activities of the AWRI.

Financial Statements – Directors' report

INFORMATION ON DIRECTORS

Directors of The Australian Wine Research Institute in office at any time during or since the end of the year:

Name and qualifications and experience	Special responsibilities	No. of Director's meetings attended	No. of Audit meetings attended	No. of N&R meetings attended
John Carlyon Angove, BSc, Chairman and Managing Director of Angove Family Winemakers, Founding member of WFA in 1988. Chairman of WFA/AWBC Wine Industry Technical Advisory Committee, member WFA medium winemakers membership committee and alternate member of WFA Executive, member of the executive of SAWIC. (From 1/1/2010)	Member of N&R Committee	2		1
James Frederick Brayne, BAppSc(Wine Science), Production Director/Chief Winemaker McWilliam's Wines Pty Ltd, National wine show judge, 36 years technical and winemaking experience in the Australian wine industry.		5		
Paul Conroy, LLB (Hons), BComm, Chief Legal Officer and Company Secretary, Foster's Group Ltd, member of the Australian Corporate Lawyers Association. Admitted as solicitor in the Supreme Courts of NSW, Victoria and the High Court of Australia, over 19 years legal and management experience working in Australia, Asia, United Kingdom and United States.	Member of Audit Committee	5	1	
Peter James Dawson, BSc**,** BAppSc(Wine Science), Principal, Peter Dawson Consulting, Chairman and Managing Director of Taransaud Australasia, Member WFA Innovation Policy Committee, Tasmanian wine producer, formerly Senior Vice President Group Operations and Technical Constellation Wines, Adjunct Professor, Faculty of Science and Technology, Deakin University, National wine show judge, 32 years technical and winemaking experience in the Australian wine industry.	Chairman, Member of N&R Committee	6		1
Geoffrey Raymond Linton, BAppSc (App Chem), GradDip (Systems Analysis), Manager, Technical and Research, The Yalumba Wine Company, member of the Wine Industry Technical Advisory Committee (AWBC, WFA), 36 years experience in the Australian wine industry.	Member of N&R Committee	6		1
James Anthony Lumbers, BSc, Lit B (public policy), Principal, Lumbers Consulting and Chairman Lerida Estate. Associate Principal of Partners in Performance, member of Canberra and District Wine Industry Association, Canberra and District Vignerons Association, ASVO and AIAS.	Member of Audit Committee	7	1	
Brett Malcolm McKinnon, BAgSc (Oenology) (Hons), Managing Director, Orlando Wines, Executive Member SA Wine Industry Association, Member SA Wine Industry Council, ASVO Professional Member, Graduate Leadership in Innovation Program INSEAD France, 22 years technical, winemaking, viticulture and commercial experience.		4		
Jan Sheree O'Connor, BEd (PE), MAICD, Managing Director, O'Connor Harvesting, Committee Member, Robinvale and District Wine Grape Growers Association, Committee Member, Murray Valley Winegrowers Inc, and the Murray Valley Industry Development Committee, 24 years experience in the Australian wine industry.		6		
Isak Stephanus Pretorius, BSc Agric (Hons) PhD, Managing Director, The Australian Wine Research Institute Ltd, Professor Extraordinary in Oenology, University of Stellenbosch, Affiliate Professor in Oenology, University of Adelaide, Committee Member: Wine Industry Technical Advisory Committee (WFA/AWBC), Wine Committee Royal Agricultural and Horticultural Society (South Australia), Member, International Commission of Yeasts, Scientific Board of L'Institutdes Sciences de la Vinge et du vin (ISVV) Bordeaux, France, Scientific Committee, Institut Catalá de Recerca en Enologia i Viticultura (ICREV) Tarragona Spain, Editorial Board Member, *American Journal of Enology and Viticulture, Annals of Microbiology, FEMS Yeast Research,* and *South African Journal of Enology and Viticulture,* and Chair of the Australian Wine Industry Technical Conference, 32 years experience in microbiology and biotechnology.	Managing Director	7		
John Wilcox Stocker, AO MBBS PhD FRACP FTSE, Chairman CSIRO, Director of Telstra Corporation Ltd, Nufarm Limited and Foursight Associates Ltd. Previously Chairman of the Grape and Wine Research and Development Corporation and Sigma Company Ltd, a director of Walter and Eliza Hall Institute of Medical Research and a director of Cambridge Antibody Technology Plc (to 6/10/2009)	Chairman, Member N & R Committee	3		2
Mark Richard Watson, BEc, MBA, ACA, IPAA, AICD Partner KPMG, previously CFO Wirra Wirra and Manager, Corporate Strategy and Development, FH Faulding & Co Ltd.	Chair Audit Committee	7	1	

Name and qualifications and experience	Special responsibilities	No. of Director's meetings attended	No. of Audit meetings attended	No. of N&R meetings attended
Alternate Directors				
Nigel Peter Blieschke, BAppSc, GradCertVit, Viticultural Manager, Peter Lehman Wines.				
Corey Brett Ryan, Group Chief Winemaker McWilliam's Wines (from 18/5/2010)		1		
Alexander Nikolai Sas, BSc Agric (Hons), Regional Viticulturist, Constellation Wines, 20 years experience in viticultural R&D and grape supply management.		1		
Secretary				
Hans Englebert Muhlack BEc CPA, 35 years experience in finance and administration in the wine industry		5	1	
Seven Board meetings, one Audit and one Nomination and Remuneration (N&R) Committee meeting were convened during the year.				

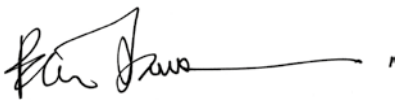
Indemnification of officers and auditors

The Company has not, during or since the end of the year, in respect of any person who is or has been an officer or auditor of the chief entity or a related body corporate indemnified, or made any relevant agreement for indemnifying, against a liability, including costs and expenses, in successfully defending legal proceedings, or paid, or agreed to pay, a premium in respect of a contract insuring against a liability for the costs or expenses to defend legal proceedings.

Auditor's independence declaration

The auditor's independence declaration under section 307C is attached.

Signed in accordance with a resolution of the Board of Directors this 21st day of September 2010.



P.J. Dawson
Chairman

Professor I.S. Pretorius
Managing Director

THE AUSTRALIAN WINE RESEARCH INSTITUTE LTD

A Company limited by Guarantee

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 30 JUNE 2010

	Notes	2010 $	2009 $
Revenue from operating activities			
Grape and Wine Research and			
Development Corporation			
Investment Agreement Project Funding		9,807,673	9,639,153
Other Project Funding		650,700	187,695
Other Capital Funding		245,806	458,571
Other Grant Funding		447,889	1,400,836
Commercial Services		2,248,981	1,817,918
Contract Research and other Commercial Income		1,209,474	1,124,327
Interest income		237,299	290,256
Other revenue		102,779	162,047
Total Revenue		14,950,601	15,080,803
Expenses from operating activities			
Employee benefit expense		10,003,691	8,860,702
Analytical and Project Operating expenses		2,408,029	1,940,354
Infrastructure and general services expenses		863,163	1,025,645
Depreciation and amortisation expense	4 & 5	1,207,482	1,054,648
Travel expenses		405,759	351,882
Total Expenses		14,888,124	13,233,231
Profit for the year		62,477	1,847,572
Net gain (loss) on disposal of assets			
Motor vehicles			-
Buildings			675,717
Other		(654)	(17,907)
Profit from ordinary activities		**61,823**	**2,505,382**
Other Comphrehensive Income		-	-
Total Comprehensive Income for the year		**61,823**	**2,505,382**

The Statement of Comprehensive Income should be read in conjunction with the accompanying notes.

THE AUSTRALIAN WINE RESEARCH INSTITUTE LTD

A Company limited by Guarantee

STATEMENT OF CHANGES IN EQUITY FOR THE YEAR ENDED 30 JUNE 2010

	Retained Earnings
As at 1 July 2008	**9,161,076**
Total Comprehensive Income for the year	2,505,382
Total recognised income and expenses for the period	2,505,382
Transferring reserves to retained earnings	
As at 1 July 2009	**11,666,458**
As at 1 July 2009	11,666,458
Profit for the year	61,823
Total recognised income and expenses for the period	61,823
Transferring reserves to retained earnings	-
As at 1 July 2010	**11,728,281**

THE AUSTRALIAN WINE RESEARCH INSTITUTE LTD

A Company limited by Guarantee

STATEMENT OF FINANCIAL POSITION AS AT 30 JUNE 2010

	Notes	2010 $	2009 $
Current assets			
Cash assets		6,688,352	5,490,411
Trade and other Receivables	2	2,098,363	1,818,366
Other current assets	3	155,554	201,126
Total current assets		8,942,269	7,509,903
Non current assets			
Plant and equipment	4	3,198,564	3,624,234
Interest in WIC Building	5	5,775,979	5,979,251
Total non current assets		8,974,543	9,603,485
TOTAL ASSETS		17,916,812	17,113,388
Current liabilities			
Payables and accruals	6	4,115,082	3,441,443
Project funds not expended and repayable			
GWRDC	7	47,904	269,566
Provisions	8	1,701,451	1,420,892
Total current liabilities		5,864,437	5,131,901
Non current liabilities			
Payables and accruals	6	41,000	58,340
Provisions	8	283,094	256,689
Total non current liabilities		324,094	315,029
TOTAL LIABILITIES		6,188,531	5,446,930
NET ASSETS		11,728,281	11,666,458
EQUITY			
Retained earnings	10	11,728,281	11,666,458
TOTAL EQUITY		11,728,281	11,666,458

The Statement of Financial Position should be read in conjunction with the accompanying notes.

THE AUSTRALIAN WINE RESEARCH INSTITUTE LTD

A Company limited by Guarantee

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 30 JUNE 2010

	Notes	2010 $	2009 $
CASH FLOWS FROM OPERATING ACTIVITIES			
Grants and other income		14,711,873	12,848,324
Interest received		253,688	290,256
Payments to suppliers and employees		(13,201,322)	(12,050,049)
Net cash provided by operating activities	11	1,764,239	1,088,531
CASH FLOWS FROM INVESTING ACTIVITIES			
Proceeds from commercial bills		-	2,908,845
Payments for Plant, Equipment and Interest in WIC Building		(568,770)	(6,098,185)
Proceeds from sale of plant and equipment		14,145	2,024,100
Net cash used in investing activities		(554,625)	(1,165,240)
CASH FLOWS FROM FINANCING ACTIVITIES			
Repayment of loans		(11,673)	(9,783)
Net cash used by financing activities		(11,673)	(9,783)
Net increase (decrease) in cash held		1,197,941	(86,492)
Cash at 1 July 2009		5,490,411	5,576,903
Cash at 30 June 2010		6,688,352	5,490,411

The Statement of Cash Flows should be read in conjunction with the accompanying notes.

Notes to and forming part of the financial statements

1 STATEMENT OF ACCOUNTING POLICIES

The financial statements have been prepared in accordance with applicable accounting standards, other mandatory professional reporting requirements and the Corporations Act 2001. The financial statements have also been prepared on the basis of historical costs and do not take into account changing money values. Where necessary, comparative information has been reclassified to achieve consistency in disclosure with current financial year amounts and disclosures.

Australian Accounting Standards include Australian equivalents to International Financial statement Standards (IFRS). Compliance with the Australian equivalents to IFRS (AIFRS) ensures that the financial statements comply with IFRS. No new Standards or Interpretations that have been issued but not adopted have been used in the preparation of these Financial statements.

The following is a summary of the significant accounting policies adopted by the AWRI in the preparation of the Financial statements.

(a) Receivables and revenue recognition

Sales are recorded when goods or services have been provided to a customer.

Trade debtors are recognised at the amount receivable and are due for settlement within 30 days from the date of the invoice.

(b) Non-current assets

The cost method of accounting is used for the acquisition of assets. The acquisition of assets must be initiated by a purchase order.

The carrying amounts of non-current assets are reviewed at balance date to ensure that they are not valued in excess of their recoverable amount.

Plant and equipment is depreciated on a straight line basis to write off the net cost of each item of plant and equipment over its expected useful life. The expected useful lives are between 3 and 10 years.

Buildings and improvements are valued at cost and amortised over the estimated useful life of the building of 30 years.

(c) Payables and expenditure recognition

Purchases are recorded when a supplier has supplied goods or services. Trade creditors are unsecured and usually paid within each supplier's trading terms.

(d) Employee entitlements

(i) Wages, salaries and annual leave

Wages, salaries, annual leave and other employee benefits expected to be settled within twelve months of the reporting date are measured at their nominal amounts, including related on-costs.

(ii) Long service leave

Long service leave liabilities expected to be settled more than twelve months after the reporting date are measured such that the liability is not materially different from the estimate determined by using the present value of the estimated future cash outflows in respect of services provided up to the reporting date.

(e) Leases

Leases of fixed assets, where substantially all the risks and benefits incidental to the ownership of the asset, but not the legal ownership, are transferred to the entity are classified as finance leases.

Finance leases are capitalised, recording an asset and a liability equal to the present value of the minimum lease payments, including any guaranteed residual values.

Leased assets are depreciated on a straight-line basis over their estimated useful lives where it is likely that the entity will obtain ownership of the asset. Lease payments are allocated between the reduction of the lease liability and the lease interest expense for the period.

Lease payments for operating leases, where substantially all the risks and benefits remain with the lessor, are charged as expenses in the period in which they are incurred.

Lease incentives under operating leases are recognised as a liability and amortised on a straight-line basis over the life of the lease term.

(f) Impairment

At each reporting date, the entity reviews the carrying values of its tangible and intangible assets to determine whether there is any indication that those assets have been impaired. If such an indication exists, the recoverable amount of the asset, being the higher of the asset's fair value less costs to sell and value in use, is compared to the asset's carrying value. Any excess of the asset's carrying value over its recoverable amount is expensed to the Statement of Comprehensive Income. No adjustments for impairment were made this year.

Where the future economic benefit of the asset is not primarily dependent upon on the asset's ability to generate net cash inflows and when the entity would, if deprived of the asset, replace its remaining future economic benefits, value in use is depreciated replacement cost of an asset.

Where it is not possible to estimate the recoverable amount of an asset's class, the entity estimates the recoverable amount of the cash-generating unit to which the class of assets belong.

(g) Cash and Cash Equivalents

Cash and cash equivalents include cash on hand, deposits held at-call with banks, other short-term highly liquid investments with original maturities of three months or less, and bank overdrafts. In July 2010, Term Deposit Accounts for terms of six and twelve months were established of $500,000 and $4,500,000 respectively were transferred into these accounts from the at-call account.

	2010 $	2009 $
2 RECEIVABLES		
Trade debtors	1,641,948	1,662,085
Other debtors	456,415	156,281
	2,098,363	1,818,366
3 OTHER CURRENT ASSETS		
Course materials	47,142	49,915
Prepayments	108,412	151,211
	155,554	201,126

4 NON CURRENT ASSETS: AMORTISATIONANDDEPRECIATION

Plant and equipment		
Opening written down value	3,624,234	2,466,634
Additions	593,339	2,120,999
Disposals	(14,799)	(42,007)
Depreciation expense	(1,004,210)	(921,392)
Closing Written down value	3,198,564	3,624,234
Buildings		
Opening written down value	-	1,336,650
Additions	-	-
Disposals	-	(1,324,283)
Depreciation expense	-	(12,367)
Closing Written down value	-	-

Proceeds on disposal of plant and equipment were $14,145 in 2010 and $24,100 in 2009.

5 INTEREST IN WIC BUILDING

AWRI has a 50 year nominal occupancy right to approximately 53% of the space in the WIC Central building owned by the University of Adelaide. The other occupants are the University of Adelaide and SARDI. The term of occupancy is reviewable after 30 years based on the remaining economic life of the building. The value assigned to the AWRI's interest in the building as at 30 June 2010 is $9.5m less the $3.4m contributed by the GWRDC.

The South Australian State Government has also contributed $9.5m to the cost of the building on behalf of all interested parties.

The Building cost will be amortised over a period of 30 years from the date of practical completion (26 November 2008).

Opening written down value	5,979,251	1,994,596
Additions (building calls)		4,105,544
Disposals		
Amortisation expense	(203,272)	(120,889)
Closing Written down value	5,775,979	5,979,251

	2010	**2009**
	$	**$**

6 PAYABLES AND OTHER ACCRUALS

Current		
Trade creditors	593,852	657,162
Income received in advance	581,038	883,017
PAYG and GST	319,876	409,563
Other creditors and accruals	2,599,976	1,480,028
Lease Liability	20,340	11,673
	4,115,082	3,441,443
Non current		
Other creditors	41,000	38,000
Lease liability	-	20,340
	41,000	58,340

	2010	**2009**
	$	**$**

7 PROJECT FUNDS NOT EXPENDED

GWRDC Funding unexpended	47,904	269,566

Any unexpended GWRDC funding other than core equipment funding is reimbursable to the GWRDC, except where the Joint Agreement Committee agrees that amounts can be retained by the AWRI for purposes approved by the Joint Agreement Committee.

There were no unspent funds from Investment Agreement funding in 2010. The unspent Investment Agreement funds for 2009 were $269,566.

There was unspent funds from other GWRDC contracts of $47,904 in 2010.

During the year, approval was given by the Joint Agreement Committee to utilise the prior year's balance of $269,566.

8 PROVISIONS

Current		
Employee entitlements	1,701,451	1,420,892
Non current		
Employee entitlements	283,094	256,689
Number of Employees (FTEs)	109.9	102.5

10 RETAINED EARNINGS

Retained earnings at the beginning of the year	11,666,458	9,161,076
Profit from ordinary activities	61,823	2,505,382
Retained earnings at the end of the year	11,728,281	11,666,458

11 RECONCILIATION OF NET CASH PROVIDED BY ORDINARY ACTIVITIES WITH ORDINARY PROFIT

Profit from ordinary activities	61,823	2,505,382
Non cash flows in operating profit		
Amortisation and depreciation	1,207,485	1,054,648
(Profit) loss on the sale of buildings, plant and equipment	654	(657,810)
Changes to (reduction in) provisions	306,964	165,165
Changes in assets and liabilities		
(Increase) decrease in receivables and other current assets	(234,425)	(1,055,085)
Increase (decrease) in sundry creditors and accruals	421,738	(923,769)
Net cash provided by ordinary activities	1,764,239	1,088,531

Notes to and forming part of the financial statements

12 FINANCIAL INSTRUMENTS

Maturity analysis

Credit risk is managed by requiring new customers to complete an application for credit which seeks information about the organisation and their current trading activities to make trade reference enquiries. The application is approved if positive information is received. In the interim, work is only undertaken on a prepayment basis.

Monthly statements are issued and customers are contacted when invoices are more than 45 days overdue.

Existing customers' work is put on hold if any of their invoices are overdue more than 60 days.

Credit on seriously overdue accounts is stopped and placed in the hands of a debt collection agency as a last resort.

The ageing of trade debtors as at 30 June 2010 compared to 2009 was as follows:

	2010	2009
	$	$
Current	1,395,856	1,401,551
Overdue: less than 30 days	116,863	125,334
Overdue: 30-60 days	60,990	31,785
Overdue: more than 60 days	68,239	103,415
	1,641,948	1,662,085

Cash flow analysis

Creditors are usually paid within 30 days unless specific other arrangements are entered into.

Should any large foreign currency payment be required, exchange rate movements are usually hedged by taking out an appropriate forward exchange contract.

The balance of the working account is checked daily and money is transferred from the Business Online Saver Account, if anticipated payments are likely to reduce the balance of the working account under $100,000. Major funding income is deposited into the Business Online Saver Account, to take advantage of the higher interest rates offered by this account.

Sensitivity analysis

Given the strong cash position and minimal gearing of the AWRI finances, the impact of a 2% interest rate movement would equate to $120,000 over a twelve month period

13 REMUNERATION OF KEY MANAGEMENT PERSONNEL

Key management personnel comprise directors and other persons having authority and responsibility for planning, directing and controlling the activities of the AWRI.

Short-term employee benefits	1,574,666	1,409,832
Post-employment benefits	144,836	155,004
Total	1,719,502	1,564,836

14 AUDITORS REMUNERATION

(a) For auditing the Financial statement	15,500	14,935
(b) For other services	3,998	6,925
	19,498	21,860

15 RELATED PARTIES

The following directors held office during the year:

Directors	Alternate Directors
John Wilcox Stocker	
Jan Sheree O'Connor	
Paul David Conroy	
Geoffrey Raymond Linton	Nigel Peter Blieschke
James Frederick Brayne	Corey Brett Ryan
Peter James Dawson	Alexander Nikolai Sas
Brett Malcolm McKinnon	
John Carlyon Angove	
Mark Richard Watson	
Isak Stephanus Pretorius	
James Anthony Lumbers	

Remuneration of Directors and key management personnel is disclosed in Note 13 to these accounts.

Related Entities

Transactions between related parties

	2010	2009
	$	$
Services received from Related Entities	217,009	133,441
Consisting of;		
Australian Wine Industry Technical Conference Inc.		
Provisor Pty Ltd		
Angove's Wines		
Constellation Wines		
The Yalumba Wine Company		
Lerida Estate		
McWilliam's Wines		
Pernod Ricard Pacific		
Services provided to Related Entities	533,416	334,108
Consisting of;		
Australian Wine Industry Technical Conference Inc.		
Provisor Pty Ltd		
Constellation Wines		
The Yalumba Wine Company		
McWilliam's Wines		
Angove's Wines		
Fosters Group		
Pernod Ricard Pacific		
Lerida Estate		
Drinkwise		

Services were provided to related entities on a purely arms length commercial basis.

16 FINANCIAL REPORTING BY SEGMENTS

The AWRI operates predominantly in one industry. The principal activities in the course of the financial year were research, development, extension and commercial scientific activities in connection with winemaking and viticulture. The AWRI operates predominantly in one geographical area, being Adelaide, South Australia. One employee works out of the Sandy Bay campus of the University of Tasmania.

17 LIMITED LIABILITY

The company is limited by guarantee. In the event of the company being wound up, the liability of each member (both during the time he or she is a member and within one year afterwards) is limited to two dollars. There are currently ten members.

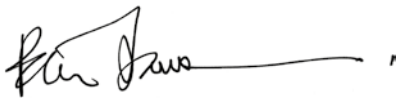
DIRECTORS' DECLARATION

In the opinion of the directors:

(a) the accompanying financial statement and notes set out on pages 50 to 62 are in accordance with the Corporations Act 2001, comply with the accounting standards and give a true and fair view of the company's financial position as at 30 June 2010 and of its performance for the year ended on that date; and

(b) at the date of this declaration there are reasonable grounds to believe that the company will be able to pay its debts as and when they become due and payable.

Signed in accordance with a resolution of the directors.



P.J. Dawson
Chairman

I.S. Pretorius
Managing Director

At Adelaide this 21st day of September 2010.

Auditor's Independence Declaration

As lead auditor for the audit of The Australian Wine Research Institute Limited for the year ended 30 June 2010, I declare that to the best of my knowledge and belief, there have been;

(a) no contraventions of the auditor independence requirements of the Corporations Act 2001 in relation to the audit; and

(b) no contraventions of any applicable code of professional conduct in relation to the audit

This declaration is in respect of The Australian Wine Research Institute Limited

PKF
Chartered Accountants

I.J. Painter
Partner

Signed in Adelaide this 21st day of September 2010.

INDEPENDENT AUDITOR'S REPORT

To the members of The Australian Wine Research Institute Limited

Report on the Financial Report

We have audited the accompanying financial report of The Australian Wine Research Institute Ltd, which comprises the statement of financial position as at 30 June 2010, and the statement of comprehensive income, statement of changes in equity and statement of cashflows for the year ended on that date, a summary of significant accounting policies, other explanatory notes and the directors' declaration.

Directors' Responsibility for the Financial Report

The directors of the company are responsible for the preparation and fair presentation of the financial report in accordance with Australian Accounting Standards (including the Australian Accounting Interpretations) and the Corporations Act 2001. This responsibility includes establishing and maintaining internal controls relevant to the preparation and fair presentation of the financial report that is free from material misstatement, whether due to fraud or error; selecting and applying appropriate accounting policies; and making accounting estimates that are reasonable in the circumstances. In Note 1, the directors also state, in accordance with Accounting Standard AASB 101 *Presentation of Financial Statements*, that compliance with the Australian Equivalents to International Financial Reporting Standards or Australian Accounting Standards ensures that the Financial report, comprising the financial statements and notes, complies with International Financial Reporting Standards.

Auditor's Responsibility

Our responsibility is to express an opinion on the Financial statement based on our audit. We conducted our audit in accordance with Australian Auditing Standards. These Auditing Standards require that we comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial report. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial report whether due to fraud or error. In making those risk assessments, the auditor considers internal controls relevant to the entity's preparation and fair presentation of the financial report in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal controls. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by the directors, as well as evaluating the overall presentation of the financial report.

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

Notes to and forming part of the financial statements

Independence

In conducting our audit, we have complied with the independence requirements of the Corporations Act 2001.

Auditor's Opinion

In our opinion the financial report of The Australian Wine Research Institute Ltd is in accordance with the Corporations Act 2001, including:

(a) giving a true and fair view of the financial position as at 30 June 2010 and of its performance for the year ended on that date; and

(b) complying with Australian Accounting Standards (including the Australian Accounting Interpretations) and the *Corporations Regulations 2001*.

PKF
A South Australian Partnership
Chartered Accountants

I.J. Painter
Partner

Signed in Adelaide this 21st day of September 2010.

Memorial Funds

THE JOHN FORNACHON MEMORIAL LIBRARY ENDOWMENT FUND

THE THOMAS WALTER HARDY MEMORIAL TRUST FUND

THE H.R. HASELGROVE MEMORIAL TRUST FUND

THE STEPHEN HICKINBOTHAM RESEARCH MEMORIAL TRUST

STATEMENT BY DIRECTORS OF THE TRUSTEE COMPANY

As detailed in note 2 to the accounts, the Trusts are not reporting entities because, in the Trustee's opinion, it is unlikely that users exist who are unable to command the preparation of reports tailored so as to satisfy, specifically, all of their information needs. This is a special purpose Financial report that has been prepared to meet the reporting obligations of the Trustee.

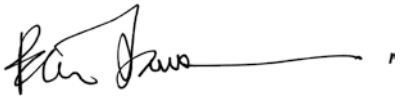
In the opinion of the directors of The Australian Wine Research Institute Ltd:

1 (a) The Statements of Comprehensive Income give a true and fair view of each Trust's surplus for the year ended 30 June 2010;

(b) The Statement of Financial Position give a true and fair view of each Trust's state of affairs as at 30 June 2010.

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

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



P.J. Dawson
Chairman

Dated this 21st day of September 2010.

Memorial Funds

STATEMENT OF COMPREHENSIVE INCOME	The John Fornachon Memorial Library Endowment Fund		The Thomas Walter Hardy Memorial Trust Fund		The H.R. Haselgrove Memorial Trust Fund		The Stephen Hickinbotham Memorial Research Trust	
For the year ended 30 June 2010	**2010 $**	**2009 $**	**2010 $**	**2009 $**	**2010 $**	**2009 $**	**2010 $**	**2009 $**
Income								
Interest	3,878	4,579	3,566	4,668	2,659	3,796	3,793	5,574
Donations	-	-	-	-	-	-	-	-
	3,878	**4,579**	**3,566**	**4,668**	**2,659**	**3,796**	**3,793**	**5,574**
Expenditure								
Advertising	-	-	-	-	-	-	-	-
Audit fees	550	550	550	550	550	550	550	550
Bank charges	-	-	-	-	-	-	-	-
Technical Review contributions	-	-	-	-	-	-	-	-
Sponsorship	-	-	-	-	-	-	-	-
	550	**550**	**550**	**550**	**550**	**550**	**550**	**550**
Profit from ordinary activities	**3,328**	**4,029**	**3,016**	**4,118**	**2,109**	**3,246**	**3,243**	**5,024**
Other Comprehensive Income	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total Comprehensive Income	**3,328**	**4,029**	**3,016**	**4,118**	**2,109**	**3,246**	**3,243**	**5,024**

STATEMENT OF FINANCIAL POSITION								
As at 30 June 2010	**2010 $**	**2009 $**	**2010 $**	**2009 $**	**2010 $**	**2009 $**	**2010 $**	**2009 $**
Current Assets								
Cash at Bank	2	2	10	10	-	-	-	-
Receivables	1,078	680	991	625	-	-	-	-
Total Current Assets	1,080	682	1,001	635	-	-	-	-
Non-Current Assets								
Investments	111,123	108,193	102,160	99,510	73,464	71,355	104,909	101,666
Total Assets	**112,203**	**108,875**	**103,161**	**100,145**	**73,464**	**71,355**	**104,909**	**101,666**
Current Liabilities								
Sundry creditors	550	550	550	550	550	550	550	550
NET ASSETS	**111,653**	**108,325**	**102,611**	**99,595**	**72,914**	**70,805**	**104,359**	**101,116**
TRUST FUNDS								
Settled Sum	12,785	12,785	50	50	20,000	20,000	50	50
Founders Donation		-	25,000	25,000	-	-	-	-
	12,785	12,785	25,050	25,050	20,000	20,000	50	50
ACCUMULATED SURPLUS								
Opening balance	95,540	91,511	74,545	70,427	50,805	47,559	101,066	96,042
Surplus for the year	3,328	4,029	3,016	4,118	2,109	3,246	3,243	5,024
Closing balance	98,868	95,540	77,561	74,545	52,914	50,805	104,309	101,066
TOTAL TRUST FUNDS	**111,653**	**108,325**	**102,611**	**99,595**	**72,914**	**70,805**	**104,359**	**101,116**

Memorial Funds

THE JOHN FORNACHON MEMORIAL LIBRARY ENDOWMENT FUND

THE THOMAS WALTER HARDY MEMORIAL TRUST FUND

THE H.R. HASELGROVE MEMORIAL TRUST FUND

THE STEPHEN HICKINBOTHAM MEMORIAL RESEARCH TRUST

1 NOTES TO AND FORMING PART OF THE ACCOUNTS

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

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

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

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

2 STATEMENT OF ACCOUNTING POLICIES

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

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

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

AAS22 Related Party Disclosures
AAS28 Statement of Cash Flows
AAS33 Presentation and Disclosure of Financial Instruments

The financial statements have been prepared on an accrual basis.

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

Investments comprise money on deposit, and are recorded at their nominal value. Interest is brought to account as earned, with accrued interest at balance date being included in the Statement of Financial position as receivables.

AUDITOR'S REPORT

TO THE TRUSTEE OF

THE JOHN FORNACHON MEMORIAL LIBRARY ENDOWMENT FUND

THE THOMAS WALTER HARDY MEMORIAL TRUST FUND

THE H.R. HASELGROVE MEMORIAL TRUST FUND

THE STEPHEN HICKINBOTHAM MEMORIAL TRUST

Scope
We have audited the financial statements, being special purpose Financial statements, of The John Fornachon Memorial Library Endowment Fund, The Thomas Walter Hardy Memorial Trust Fund, The H.R. Haselgrove Memorial Trust Fund and The Stephen Hickinbotham Memorial Research Trust for the year ended 30 June 2010, as set out on pages 60 to 62. The Trustee is responsible for the preparation and presentation of the financial statements and the information they contain and has determined that the accounting policies used and described in Note 2 to the accounts are appropriate to meet the needs of the members. We have conducted an independent audit of these financial statements in order to express an opinion on them to the members on their preparation and presentation.

Our audit has been conducted in accordance with Australian auditing standards. Our procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial statements and significant accounting estimates. These procedures have been undertaken to form an opinion as to whether, in all material respects, the financial statements are presented fairly in accordance with the accounting policies described in Note 2 to the accounts. These policies do not require the application of all accounting standards and mandatory professional reporting requirements.

The audit opinion expressed in this report has been formed on the above basis.

Audit Opinion
In our opinion, the financial statements of The John Fornachon Memorial Library Endowment Fund, The Thomas Walter Hardy Memorial Trust Fund, The H.R. Haselgrove Memorial Trust Fund and The Stephen Hickinbotham Memorial Research Trust for the year ended 30 June 2010 are properly drawn up in accordance with applicable Australian accounting standards. As the Trustee has determined that the Trusts are non-reporting entities, accounting standards and other mandatory professional reporting requirements have only been applied to the extent described in Note 2 to the accounts.

PKF
A South Australian Partnership
Chartered Accountants

I.J. Painter
Partner

Signed at Adelaide this 21st day of September 2010.

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
R.G. Dambergs	AWRI research input into the ICIP programs for vintage 2009, a preliminary review	WIT-TIAR seminar, Coal River Valley, Tas	2 Jul 2009
E.J. Waters	Wine and oxygen	*In Vino Analytica Scientia*, Angers, France	4 Jul 2009
M. Ugliano	Modulation of Shiraz volatiles and aroma ageing potential through di-ammonium phosphate addition	Katholieke Universiteit Leuven, Leuven, Belgium	7 Jul 2009
P.J. Chambers	Systems Biology: a new paradigm for industrial yeast strain development	1st Australasian Symposium on Metabolomics, Auckland, New Zealand	7 Jul 2009
	Yeast research at the AWRI	School of Biological Sciences, Auckland University, New Zealand	8 Jul 2009
M. Ugliano	Optimising wine aroma composition and style through fermentation and post-fermentation practices	University of Zaragoza, Spain	10 Jul 2009
S-J. Bell	Manipulating nitrogen in the vineyard and the impact on secondary metabolites of red grapes and wine	GiESCO (Group of International Experts of Vitivinicultural Systems for Cooperation) Conference, Davis, California, USA	15 Jul 2009
I.L. Francis	Tasting and discussion of flavour standards	28th Advanced Wine Assessment Course, Urrbrae, SA	21 Jul 2009
M.G. Holdstock	Tasting of simulated faulty wines		
R. Gawel	Palate performance and statistical evaluation		24 Jul 2009
M.G. Holdstock	Comparing cold stability methods	Interwinery Analysis Group Annual Technical Seminar, Barossa Valley, SA	
M.J. Herderich	Formation of key sulfur aroma compounds in wine	Queensland Wine Business Conference, Toowoomba, Qld	27 Jul 2009
I.S. Pretorius	Yeast strain development and effective wine fermentation management	Stellenbosch University, Stellenbosch, South Africa	
	Managing fermentation conditions to optimse performance and maximise wine quality	Fourth International South African Society of Enology and Viticulture Conference, Cape Town, South Africa	28 Jul 2009
	Wine innovation across the entire value chain		
E.J. Waters	Protein haze in white wines: new solutions to an old problem	AWRI Roadshow, University of Southern Queensland, Toowoomba, Qld	
	Impact of ullage volume under screw cap (ROTE) on chemical composition and sensory properties of a Cabernet Sauvignon wine		
M.J. Herderich	Phew! What is that stench? Low molecular weight sulfur compounds in wine		
C.A. Simos	Strategies for the control of *Brettanomyces*		
P.R. Dry	How do irrigation management strategies manipulate wine quality?		
M. Essling	Agrochemical issues for grape growers and winemakers		
	Does grapevine nutrition have an impact on wine quality?		
J.A. Kennedy	Impact of grape and wine production on grape and wine tannins: recent research and future directions		
	White juice and wine phenolics		
S. Mueller[1], P.C. Osidacz, I.L. Francis, L. Lockshin[1]	The relative importance of sensory and non-sensory product characteristics: combining discrete choice and informed sensory testing	8th Pangborn Sensory Science Symposium, Florence, Italy	
I.L. Francis	'Leather/medicinal' phenol compounds in red wine: Sensory properties and consumer acceptance		
P.C. Osidacz	Revealing Chinese consumers' of red wine preferences: a cross cultural study		

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
G.D. Cowey	Taints and contaminations	AWRI Roadshow workshop (The avoidance of taints and chemical instabilities during winemaking), University of Southern Queensland, Toowoomba, Qld	29 Jul 2009
M.G. Holdstock	Case studies		
	A tasting of wines with simulated taints and faults		
A.D. Coulter	www.awri.com.au		
G.D. Cowey	Wine taint prevention		
M.G. Holdstock	A tasting of real wines with 'real' taints		
G.D. Cowey	Methods to assess taints in winemaking additives (includes a practical component)		
A.D. Coulter	Instabilities from wine additives		
R.G. Dambergs	TIAR/ AWRI wine sector research in Tasmania	National Wine Research Network, Mildura, Vic	31 Jul 2009
C.A. Simos	The AWRI annual report	Victorian Wine Industry Association AGM, Yarra Valley, Vic	11 Aug 2009
E.J. Bartowsky	Natural fermentation: potential of alternative inoculation strategies	AWRI Roadshow, The Geelong Club, Geelong, Vic	12 Aug 2009
	MLF inoculation regimes: co-inoculation or sequential – potential wine flavour modifications		
M. Essling	Post harvest care of grapevines: irrigation, nutrition and salinity		
	Impact of nitrogen on grape and wine quality		
P.R. Dry	Understanding how vines cope with periods of hot weather and extended drought conditions		
	It's getting hotter — but should we panic?		
C.A. Simos	Quality control bottling parameters		
J.A. Kennedy	Grape maturity and tannins: the impact of viticultural treatments on grape and wine tannins		
M.J. Herderich	Metabolomics for grape and wine research	Plant and Food Research, University of Auckland, Auckland, New Zealand	14 Aug 2009
I.S. Pretorius	Yeast strain development and effective wine fermentation management	China Agricultural University, Beijing, China	15 Aug 2009
	Microbial gen*omics*, transcript*omics*, prote*omics*, and metabol*omics*: what does it all mean for wine econ*omics*?		
A.D. Coulter	Taints and contaminations	AWRI Roadshow workshop (The avoidance of taints and chemical instabilities during winemaking), The Orange Agricultural Institute Training Centre, Orange, NSW	18 Aug 2009
G.D. Cowey	Case studies		
A.D. Coulter	A tasting of wines with simulated taints and faults		
M.G. Holdstock	www.awri.com.au		
	Wine taint prevention		
G.D. Cowey	A tasting of real wines with 'real' taints		
M.G. Holdstock	Methods to assess taints in winemaking additives (includes a practical component)		
A.D. Coulter	Instabilities from wine additives		
	Taints and contaminations		
I.S. Pretorius	Wine innovation: perspectives and examples from Australia	International Wine Conference, Ningxia, China	19 Aug 2009
M.J. Herderich	Analysis and formation of key sulfur aroma compounds in wine	American Chemical Society National Conference, Washington DC, USA	
A.D. Coulter	Taints and contaminations	AWRI Roadshow workshop (The avoidance of taints and chemical instabilities during winemaking), Robert Oatley Cellar Door, Mudgee, NSW	20 Aug 2009
G.D. Cowey	Case studies		

Staff	Title of talk	Presented to and where	Date
A.D. Coulter	A tasting of wines with simulated taints and faults	AWRI Roadshow workshop (The avoidance of taints and chemical instabilities during winemaking), Robert Oatley Cellar Door, Mudgee, NSW	20 Aug 2009
M.G. Holdstock	www.awri.com.au		
	Wine taint prevention		
G.D. Cowey	A tasting of real wines with 'real' taints		
M.G. Holdstock	Methods to assess taints in winemaking additives (includes a practical component)		
A.D. Coulter	Instabilities from wine additives		
	Taints and contaminations		
I.S. Pretorius	Past, present and future – impacts of research and technology on quality wine production	2009 Romeo Bragato Conference, Napier, New Zealand	21 Aug 2009
	Overview of AWRI activities	AWRI Roadshow, Swinburne University of Technology, Yarra Valley, Vic	24 Aug 2009
M.J. Herderich	Research at the AWRI		
P.A. Smith	Development at the AWRI		
C.A. Simos	Extension at the AWRI		
D.L. Johnson	Commercialisation at the AWRI		
V.T. O'Brien	Commercial Services at the AWRI		
E.J. Waters	Stabilising and bottling wine		
I.L. Francis	Wine composition, sensory properties and consumer preferences		
P.R. Dry	Viticulture – past, present and future		
V.T. O'Brien	The importance of oxygen management at and after bottling		
C. D. Curtin	Holistic approaches to wine microbiology: Harnessing state of the art technology to enhance winemaking options		
P.A. Smith	From philosophy to practicality; an overview of development projects within the Industry Applications team		
J.A. Kennedy	The chemistry of grapes and wine: increasing knowledge to make better wine		
E.J. Bartowsky	Influence of the malolactic fermentation on sensory characteristics in Cabernet Sauvignon	Lallemand Australia-Adelaide distributors meeting, Hilton Hotel, Adelaide, SA	26 Aug 2009
S-J. Bell	Updates and issues related to the 2009/2010 publication *Agrochemicals registered in Australian Viticulture*	Peter Lehman's Pest and Disease Seminar Day, Barossa Valley, SA	2 Sept 2009
	Resistance management in viticulture		
M.G. Holdstock	Cold stability	AWRI Roadshow Workshop (A guide to trouble-free packaging), Tintara Winery, McLaren Vale, SA	
G.D. Cowey	Heat stability		
	Sulfide treatment and copper fining		
E.L. Kennedy	Wine fining practical		
	Filtration		
G.D. Cowey	Packaging		
	Real wine tasting		
A.D. Coulter	Post-bottling storage		
M.G. Holdstock	Post-bottling transport		
	Taints and contaminants	AWRI Roadshow Workshop (The avoidance of taints and chemical instabilities during winemaking), Pettaval Winery, Geelong, Vic	16 Sept 2009
A.D. Coulter	Case studies		
G.D. Cowey	A tasting of wines with simulated taints and faults		
A.D. Coulter	www.awri.com.au		

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
M.G. Holdstock	Wine taint prevention	AWRI Roadshow Workshop (The avoidance of taints and chemical instabilities during winemaking), Pettaval Winery, Geelong, Vic	16 Sept 2009
A.D. Coulter	A tasting of real wines with 'real' faults		
G.D. Cowey	Methods to assess taints in winemaking additives (included a practical component)		
M.G. Holdstock	Instabilities from wine additives		
R.A. Muhlack	Renewable energy options for the wine industry: planning for business sustainability	5th Australian Wine Industry Environment Conference, Adelaide, SA	23 Sept 2009
I.S. Pretorius	Climate change - a cool vision in a hot debate		
V.T. O'Brien	Novel analytical technologies for wineries	Wine Australia Workshop – Innovation and Regulation, Yantai, China	
	Packaging, storing and delivery advances to keep wine in optimal condition		
C.A. Varela	Biosciences at the AWRI	Universidad de Santiago, Santiago, Chile	
A.D. Coulter	Heat wave and stress in the winery	Rutherglen Winemakers Association, Rutherglen, Vic	24 Sept 2009
J.A. Kennedy	The effect of environmental factors on the development of tannins		
T.E. Siebert	Identifying the compound responsible for 'peppery' Shiraz	From Grape to Glass: The science of wine, AusBiotech seminar, AWRI, Adelaide, SA	28 Sept 2009
I.L. Francis	Salinity in the vineyard		
P.C. Osidacz	Understanding Chinese consumers' red wine preference		
E.M.C. Robinson	Quantifying Pinot Gris and Pinot Grigio wine style		
C.A. Varela	Biosciences at the AWRI	Universidad Santo Tomas, Santiago, Chile	
G.D. Cowey	Heat stability	AWRI Roadshow Workshop (A guide to trouble-free packaging), Coonawarra Soldiers' Memorial Hall, Coonawarra, SA	29 Sept 2009
	Sulfide treatment and copper fining		
E.L. Kennedy	Wine fining practical		
	Filtration		
A.D. Coulter	Filtration – wine composition		
G.D. Cowey	Packaging		
	Real wine tasting		
A.D. Coulter	Closure choice and post-bottling storage		
M.G. Holdstock	Post-bottling transport		
	Cold stability		
C.A. Varela	Biosciences at the AWRI	Universidad Catolica de Chile, Santiago, Chile	30 Sept 2009
C.A. Simos	The year in review. An overview of current research projects	AWRI Roadshow half day seminar, Swan Valley and Regional Winemakers Association, Swan Valley, WA	
D.W. Jeffery	Passion and Spice: hot topics in flavour chemistry at the AWRI		
A.D. Coulter	Heat wave and stress in the winery		
C.A. Simos	The year in review. An overview of current research projects (including findings from the 2009 Victorian fire event)	AWRI Roadshow, Swan Valley and Regional Winemakers Association, Guildford, WA	1 Oct 2009
A.D. Coulter	Heat waves and potential stresses in the winery		
I.L. Francis	Phenolics in white wines and consumer acceptance	Wirra Wirra Management Meeting, Mt Lofty, SA	6 Oct 2009
M.J. Herderich	Analysis and formation of key sulfur aroma compounds in wine	University of Auckland, Auckland, New Zealand	7 Oct 2009
M. Essling, C.A. Simos	Overview of Research to Practice	Grower Liaison Officers, Penfolds Estate, Barossa Valley, SA	
V.T. O'Brien	The importance of oxygen management at and after bottling	AWRI Roadshow Half Day Seminar, Riverina Winemakers' Association, Griffith, NSW	13 Oct 2009

Staff	Title of talk	Presented to and where	Date
C.D. Curtin	Yeast modulation of wine aroma	AWRI Roadshow Half Day Seminar, Riverina Winemakers' Association, Griffith, NSW	13 Oct 2009
J.A. Kennedy	Update on red wine phenolic research		
M. Ugliano	YAN and the art of fermentation management		
C.A. Simos	Smoke taint: a summary of the 2009 fire events		
M. Ugliano	YAN and the art of fermentation management.	AWRI Roadshow, Griffith, NSW	
V.T. O'Brien	The importance of oxygen management at and after bottling		
C.D. Curtin	Yeast modulation of wine aroma		
J.A. Kennedy	Update on red wine phenolic research		
C.A. Simos	Smoke taint; a summary of the 2009 fire events		
D.W. Jeffery	Careers at the AWRI	AusBiotech Careers evening, German Club, Adelaide, SA	14 Oct 2009
P.R. Dry	How do irrigation management strategies manipulate wine quality?	AWRI Roadshow, Canowindra, NSW	20 Oct 2009
	Insights into varietal and rootstock differences in water use		
	Vineyard management strategies for a hotter future		
S-J. Bell	Impact of nitrogen on grape and wine quality		
	Manipulation of phenolic profiles in red grapes and wine by viticultural management		
M. Essling	Understanding how vines copes with periods of hot weather and extended drought conditions		
C.A. Simos	Taints and off-flavours in wine — case studies of recent industry problems		
	Getting the best out of the AWRI website		
J.A. Kennedy	Grape maturity and tannins: the impact of viticultural treatments on grape and wine tannins		
A.R. Borneman	Characterisation of intra-specific genomic diversity in industrial microorganisms by whole-genome next-generation sequencing	The Australian Microarray and Associated Technology conference, Pokolbin, NSW	21 Oct 2009
M.G. Holdstock	Real wines — real bottling related faults	Stanthorpe Winemakers Association, Stanthorpe, Qld	22 Oct 2009
G.D. Cowey	Riesling — composition, flavours, styles and consumers and closure choice	New England Wineshow Committee, New England, NSW	23 Oct 2009
E.J. Bartowsky	Wine aroma and flavour development by *Oenococcus oeni* during malolactic fermentation	Lallemand Australia winemaker meeting, Griffith, NSW	29 Oct 2009
J.A. Kennedy	Grape maturity and tannins: the impact of viticultural treatments on grape and wine tannins	Tasmanian consortium, Campbell Town, Tas	2 Nov 2009
R. De Bei[2], D. Cozzolino, W. Sullivan[2], W. Cynkar, S. Fuentes[2], R. Dambergs, S. Tyerman[2]	Estimating leaf and stem water potentials of grapevine using near infrared spectroscopy: an application for precision irrigation scheduling	VI International Symposium on Irrigation of Horticultural Crops, Vina del Mar, Chile	
P.R. Dry	Why do we need new clones in Australia?	AWRI Roadshow, Limestone Coast Wine Industry Council, Struan, SA	4 Nov 2009
	Vine balance and wine quality		
M. Marangon	The link between bentonite requirements and vineyard and winemaking practices		
I.S. Pretorius	Effective fermentation management and yeast strain development		

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
M. Essling	How do irrigation management strategies manipulate wine quality?	AWRI Roadshow, Limestone Coast Wine Industry Council, Struan, SA	4 Nov 2009
	Manipulation of phenolic profiles in red grapes and wine by viticultural management		
D.W. Jeffery	Impact of grape and wine production on grape and wine tannins, recent research and future directions		
	Pepper aroma in Shiraz		
P.A. Henschke	Wild yeast fermentation: potential for alternative inoculation strategies		
E.J. Bartowsky	Wine aroma and flavour development by *Oenococcus oeni* during malolactic fermentation	Lallemand Australia winemaker meeting, Hunter Valley, NSW	5 Nov 2009
M. Ugliano	YAN and wine aroma composition.	2009 Foster's Group Winemakers Technical Conference, Magill, SA	
P.A. Henschke	Nitrogen management and fermentation H_2S: causes and mechanisms		
M. Parker, Y. Hayasaka	Current progress of smoke affect research in response to industry needs		
E.M.C. Robinson	Quantifying and predicting Pinot Grigio/Gris wine 'style'		6 Nov 2009
P.A. Smith	An overview of Industry Applications development projects		
P.W. Godden	Objectively defining the Pinot Grigio /Gris continuum — development of a tool to help communicate wine style differences to the wine trade and to consumers	Alternative Varieties Wine Show Seminar, Mildura, Vic	
D. Cozzolino	Use of NIR to measure leaf water potential	14th International NIR Conference, Bangkok, Thailand	7 Nov 2009
M.G. Holdstock	Cold stability	AWRI Roadshow Workshops (A guide to trouble-free packaging), Barossa Valley, Tanunda, SA	10 and 11 Nov 2009 (two workshops)
G.D. Cowey	Heat stability		
	Sulfide treatment and copper fining		
M.G. Holdstock	Wine fining practical		
A.D. Coulter	Filtration		
	Controlling microbiological activity		
G.D. Cowey	Packaging		
	Real wine tasting		
A.D. Coulter	Closure choice and post-bottling strategies		
M.G. Holdstock	Post-bottling transport		
I.S. Pretorius	Wine-omics: the pathway to the future of wine research	Universidad de la Republica, Montevideo, Uruguay	10 Nov 2009
	Bridging the gap between the idea and its transformation into commercial outcomes in the wine industry	Congress Latino Americano de Viticultura y Enologia, Montevideo, Uruguay	12 Nov 2009
	Effective wine fermentation management		
P.R. Dry	Alternate varieties	AWRI Roadshow, Barossa Valley Tanunda, SA	
	Vine balance, yield and wine quality		
M. Essling	Understanding how vines cope with periods of hot weather and extended drought conditions		
	Sustainable salinity management in your vineyard		
	Vineyard management strategies for a hotter future		
I.L. Francis	Consumer preferences for Australian Shiraz and Cabernet Sauvignon wines	AWRI Roadshow, Barossa Valley Tanunda, SA	12 Nov 2009
S-J. Bell	Does grapevine nutrition have an impact on wine quality?		
C.A. Simos	Using the AWRI website and accessing world-wide technical information resources on grape and wine		

Staff	Title of talk	Presented to and where	Date
A.R. Borneman	Genomics of wine microorganisms	Bioplatforms Australia Wine Yeast Systems Biology Workshop, AWRI, Adelaide, SA	13 Nov 2009
I.L. Francis	Wine faults	Blackwood Home Winemakers and Brewers Club, Blackwood, SA	14 Nov 2009
P.R. Dry	Varietal nomenclature	International Wine Law Association Conference, Barossa Valley, SA	15 Nov 2009
D. Cozzolino, W. Cynkar, N.K. Shah	Vintage collaboration trial; Petaluma Winery — AWRI	Petaluma Winery, Adelaide Hills, SA	16 Nov 2009
M.J. Herderich	Wein aroma chemie am AWRI — Australian style und terroir	Forschungsanstalt Geisenheim, Germany	
G.D. Cowey	Handling high sugars — overview of the impact of high grape sugar	Bendigo Winegrowers Association, Bendigo, Vic	18 Nov 2009
	Processing ripe fruit — working with high sugars in the winery		
R.G. Dambergs	ICIP research update	Wine Industry Tasmania Field Day, Moorilla winery, Hobart, Tas	19 Nov 2009
P.W. Godden	Objectively defining the Pinot Grigio /Gris Continuum — development of a tool to help communicate wine style differences to the wine trade and to consumers		
M.J. Herderich	Yeast activity and wine quality: microbial formation of key sulfur aroma compounds in wine	2nd International Symposium – Microsafetywine, Martina Franca, Italy	
E.J. Bartowsky, C.S. Stockley	Managing biogenic amines in Australian wines		20 Nov 2009
A.R. Borneman	Wine yeast genomics	First Annual Wine Innovation Cluster Research Day, Waite Campus, Adelaide, SA	
D. Cozzolino	Developments and applications of spectroscopy for the grape and wine industry		
M. Ugliano	Nitrogen management in the vineyard and in the winery — managing wine aroma composition and style		
I.L. Francis	Wine composition, sensory properties and consumer preference		
E.J. Bartowsky	Success of Australian oenology: the benefits of research	Universitat Rovira i Virgili, Dept. Bioquimica i Biotecnologia, Facultat d'Enologia de Tarragona, Tarragona, Spain	23 Nov 2009
C.S. Stockley	Can moderate wine consumption positively influence human health?	University of Adelaide's Wine 2030 Wine and Health Workshop, Urrbrae, SA	
M.G. Holdstock	Cold stability	AWRI Roadshow Workshop (A guide to trouble-free packaging), The Valleys Lifestyle Centre, Clare Valley, SA	24 Nov 2009
G.D. Cowey	Heat stability		
	Sulfide treatment and copper fining		
M.G. Holdstock	Wine fining practical		
A.D. Coulter	Filtration		
	Controlling microbiological activity		
G.D. Cowey	Packaging		
	Real wine tasting		
A.D. Coulter	Closure choice and post-bottling strategies		
M.G. Holdstock	Post-bottling transport		
G.D. Cowey	Topical flavours in 2009	Institute of Masters of Wines, Adelaide, SA	25 Nov 2009
E.J. Bartowsky	Success of Australian oenology: the benefits of research	Universidad Castilla-La Mancha, Ciudad Real, Spain	26 Nov 2009
M. Essling	Vineyard management strategies for a hotter future	AWRI Roadshow, Clare Valley, SA	
	Insights into varietal and rootstock differences in water use		

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
E.J. Waters	The link between bentonite requirements and vineyard and winemaking practices	AWRI Roadshow, Clare Valley, SA	26 Nov 2009
P.A. Henschke	Wild yeast fermentation: potential for alternative inoculation strategies		
E.J. Waters	Wine development in bottle — impact of closures, storage conditions and ascorbic acid addition		
C.A. Varela	Development of low alcohol yeast — progress report		
J.A. Kennedy	Impact of grape and wine production on grape and wine tannins, recent research and future directions		
P.W. Godden	Strategies for the control of *Dekkera/Brettanomyces*, during winemaking		
P.C. Osidacz	Consumer preferences for Australian Shiraz and Cabernet Sauvignon wines		
R.G. Dambergs	Agricultural science and winemaking	Primary Industry Centre for Science Education (PICSE) workshop, UTAS, Cradle Coast Campus, Burnie, Tas	1 Dec 2009
C.A. Varela	Systems Biology: a new approach to industrial yeast strain development	4th Australian Conference on Yeast: Products and Discovery 2009, Adelaide, SA	2–4 Dec 2009
T.G. Cordente	Identification and characterisation of a novel flavour active gene in *Saccharomyces cerevisiae*: *STR3*		
A.R. Borneman	Genome sequencing and comparative genomics of industrial *Saccharomyces cerevisiae* strains		
T.T.M.T. Tran	Identification and characterisations of genes that confer ethanol tolerance in *Saccharomyces cerevisiae*		
C.D. Curtin	Genetic diversity and sulfite tolerance of *Dekkera bruxellensis* isolates from Australian wineries		
P.J. Van Eyk[3], R.A. Muhlack, P.J. Ashman[3]	Gasification of grape marc in a circulating fluidised bed	Australian Combustion Symposium, University of Queensland, Brisbane, Qld	
M. Parker	Smoke taint: New research findings	Orlando Wines pre-vintage conference, Richmond Grove, Barossa Valley, SA	3 Dec 2009
G.D. Cowey	Salt — current research and future directions		
D. Cozzolino, W.U. Cynkar, N.K. Shah, P.W. Godden, I.S. Pretorius	BevScan for wine analysis	South Australian Wine Industry Association Board, Adelaide, SA	11 Dec 2009
R.G. Dambergs	ICIP research update	Wine Industry Tasmania Field Day, Josef Chromy Wines, Relbia, TAS	11 Jan 2010
		Wine Industry Tasmania Field Day, Coal Valley Vineyards, Cambridge, TAS	13 Jan 2010
C.D. Curtin	Influence of yeast upon Chardonnay aroma and consumer preferences	Lallemand Tour, France	18–22 Jan 2010
M. Ugliano, M.J. Kwiatkowski, I.L. Francis, B. Travis, D.W. Jeffery, T.E. Siebert, D. Capone, M.R. Solomon, E.J. Waters	Avoiding 'reduced' aromas in bottled wines	Nomacorc Closure Council Meeting, Davis, California, USA	25 Jan 2010
	Avoiding reduction in bottled wines	Oxygen Management Conference: From a static to a dynamic view of oxygen in wine, Napa, California, USA	26 Jan 2010
M. Ugliano, M.J. Kwiatkowski, E.J. Waters	Wine development post bottling: data from the 2009 bottling trial–the 6-month time point	Nomacorc Post Bottling Chemistry Research Consortium, Davis, CA, USA	27 Jan 2010
J.A. Kennedy	Vineyard practices for wine quality: are we getting there?	Unified Wine and Grape Symposium, Sacramento, California, USA	

Staff	Title of talk	Presented to and where	Date
M.J. Herderich	Spice up your life: pepper aroma in Shiraz	New Zealand Syrah Symposium, Hawke's Bay, New Zealand	30 Jan 2010
J.A. Kennedy	Overview of the AWRI: recent research	E&J Gallo Winery, Modesto, California, USA	31 Jan 2010
	The Australian wine industry and research at The Australian Wine Research Institute	Oregon State University, Corvallis, Oregon, USA	2 Feb 2010
	The chemistry of tannin quality in red wine: are we getting closer to a definition?	University of California, Davis, USA	5 Feb 2010
I.S. Pretorius	Prospects for growth and adaptation by 2030 via R&D	2010 AARES Conference, Adelaide, SA	8 Feb 2010
P.W. Godden	Objectively defining the Pinot Grigio /Gris Continuum — development of a tool to help communicate wine style differences to the wine trade and to consumers	The Australian Sommeliers Association, Melbourne chapter, Circa restaurant, St. Kilda, Vic	15 Feb 2010
E.J. Waters	History of wine and oxygen research at the AWRI, as at Feb 2010	O2 in Wines Australian Chapter. Adelaide, SA	24 Feb 2010
C.S. Stockley	Addition of resveratrol to wine	OIV Wine Technology Expert Group meeting, Paris, France	9 Mar 2010
J.R. Bellon	AWRI research into interspecific wine yeast hybrids	Sherbrook Laboratory (Yeast Genetics), Department of Genetics, Stanford University, California, USA	10 Mar 2010
C.S. Stockley	Bioavailability of wine-derived phenolic compounds	OIV Consumption, Nutrition and Health Expert Group meeting, Paris, France	11 Mar 2010
P.J. Chambers	Recent and future developments in wine research: a microbiological perspective	Victoria Brewing Society Meeting, Ballarat University, Ballarat, Vic	
C.S. Stockley	Wine quality and safety regulations	Corkwise wine seminar, Campden/BRI, Surrey, UK	15 Mar 2010
	Can moderate wine consumption really have a significant effect on human health?	School of Medicine and Dentistry and the Rowett Institute of Nutrition and Health at the University of Aberdeen, UK	18 Mar 2010
J.A. Kennedy, R.W. Durst[4], J.L. Koerner[5], B.W. Smith[6], R.E. Wrolstad[5]	Suitability of grape-derived phenolic compounds for determining wine varietal authenticity	Spring meeting of the American Chemical Society, San Francisco, California, USA	21 Mar 2010
J.A. Kennedy	Getting a grip on red wine tannins		
I.S. Pretorius	Controlling the highs and lows of alcohol in wine	Albert Einstein College of Medicine, New York, USA	22 Mar 2010
		International Intervitis Interfructa Conference 2010, Stuttgart, Germany	24 Mar 2010
E.J. Bartowsky	Influence of malolactic fermentation on the fruity characters of red wine – bringing wine chemistry and sensory together		26 Mar 2010
	Strain specific sensory contribution to red wine aroma	DLR RheinlandPfalz, Neustadt, Germany	30 Mar 2010
		Badischer Winzerkeller, Breisach, Germany	31 Mar 2010
G.D. Cowey	Riesling and Tempranillo	South Australian Wine Guild, North Adelaide Primary School, North Adelaide, SA	11 Apr 2010
D.L. Capone, M.J. Herderich, K.H. Pardon, Y. Hayasaka, A.G. Cordente, P.A. Grant-Preece[7], M.A. Sefton[2], G.M. Elsey[2], D.W. Jeffery	Formation of varietal thiol aroma compounds in wine: synthetic and analytical studies of grape and wine conjugates	9th Wartburg Symposium on Flavour Chemistry and Biology, Eisenach, Germany	16 Apr 2010
D. Cozzolino	Near infrared spectroscopy and its role in a sustainable wine production	14th Australian Near Infrared Spectroscopy Conference, Adelaide, SA	19–21 Apr 2010
P.A. Smith	Tannin and its roles in wine composition and sensory properties	Hawkes Bay Winegrowers Association, Napier, New Zealand	19 Apr 2010

Appendix 1 – External presentations and talks

Staff	Title of talk	Presented to and where	Date
M.G. Holdstock	Simulated flavours, faults, taints and mouth-feel tasting	Magill Estate restaurant staff, Magill Estate, Magill, SA	10 May 2010
D.L. Johnson	Potential collaborative projects between AWRI and Oenobrands	Oenobrands staff, Montpellier, France	11 May 2010
W. Roget, K. Forsyth	Refrigeration efficiency research outcomes and total package oxygen measurement	Wine workshop on oxygen management and refrigeration efficiency, Hobart, Tas	18 May 2010
D.L. Johnson	Wine R&D, a major background contributor in Australian winemaking	Dijon Business School, Masters of Wine students, London, UK	19 May 2010
I.S. Pretorius	Wine innovation: perspectives and examples from Australia	Constellation Wines Internal Technical Conference, Santa Cruz, California, USA	
G.D. Cowey	Heat stability	AWRI Roadshow workshop (A guide to trouble free packaging for winemakers), Merilba Estate, Uralla, New England/Armidale, NSW	
M.G. Holdstock	Cold stability		
A.D. Coulter	Sulfide treatment and wine fining practical		
G.D. Cowey	Packaging preparation		
A.D. Coulter	Controlling microbiological activity		
M.G. Holdstock	Line sanitation & filtration		
G.D. Cowey	Packaging operation		
	Real wine tasting		
A.D. Coulter	Closure choice and post-bottling storage		
M.G. Holdstock	Post bottling transport		
I.S. Pretorius	Yeast strain development and effective fermentation management for the production of consumer-preferred wine styles	Faculty and students of UC Davis, UC Davis, California, USA	20 May 2010
S-J. Bell	Impact of nitrogen on grape and wine quality	AWRI Roadshow Seminar Armidale – New England, Merilba Estate, Uralla, NSW	
	Does grapevine nutrition have an impact on wine quality?		
	Manipulation of phenolic profiles in red grapes and wines by viticultural management		
P.R. Dry	Vine balance, yield and wine quality		
	Understanding how vines cope with periods of hot weather and extended drought conditions		
C.A. Simos	Winemaking—understanding the basics and whole lot more! (Part I)		
	Winemaking—understanding the basics and whole lot more! (Part II)		
	How the AWRI website can help you		
E.J. Bartowsky	MLF inoculation regimes—affect on sensory and chemical composition		
J.A. Kennedy	Grape and wine phenolics		
I.S. Pretorius	Beyond the idea …	UC Davis Board of Visitors and Fellows, UC Davis, California, USA	21 May 2010
	Frontier yeast fundamentals fizz up a phenomenal fuss for the future of wine ferment	ASM 110th Annual General Meeting, San Diego, California, USA	24 May 2010
W. Roget, K. Forsyth	Technology in a bottle – winery operations improvement opportunities	Wine Innovation Cluster, Urrbrae, SA	25 May 2010
P.W. Godden	Shining some light on wine innovation	InfoWine Forum, Vila Real, Portugal	26 May 2010
I.S. Pretorius	The rise of fizz - frontier science, yeast and wine	Genomics Forum, Genome BC, Vancouver, Canada	28 May 2010

Staff	Title of talk	Presented to and where	Date
M. Marangon	Purification, crystallization and preliminary X-ray diffraction studies of four thaumatin-like protein isoforms from *Vitis vinifera* grape juice	UMR SPO, INRA, Montpellier, France	10 Jun 2010
E.J. Waters	Grape and wine proteins		
I.S. Pretorius	The AWRI Annual Report presentation	Wine Industry Tasmania, Hobart, Tas	17 Jun 2010
K. Forsyth	Using ISO14440 – A case study in flexible wine packaging	Australian Institute of Packaging, Adelaide, SA	
M. Marangon	Effects of ionic strength and sulfate upon thermal aggregation of grape chitinases and thaumatin-like proteins in model system	Macrowine, Turin, Italy	16 Jun 2010
K. Bindon	Toward a model of grape proanthocyanidin extraction during vinification		18 Jun 2010
M. Ugliano	Influence of fermentation and post-fermentation oenological variables on wine aroma composition and sensory properties		
M. Parker	New research findings (smoke taint)	Constellation Wines Australia, Reynella, SA	22 Jun 2010
M. Essling	An agrochemical update and best practice botrytis management	Queensland viticulture seminar: Winter 2010, Stanthorpe, Qld	
S-J. Bell	Vine nutrient status can affect wine quality	Farmer John's Viticulture Seminar 2010, Nurioopta, SA	25 Jun 2010
I.L Francis	Consumer preferences for Australian Shiraz and Cabernet Sauvignon wines		
E.J. Bartowsky	Genotypic diversity in the malolactic fermentation bacterium *Oenococcus oeni*	11th International Symposium on the Genetics of Industrial Microorganisms, Melbourne, Vic	28 Jun 2010
P.J. Chambers	Systems Biology: a new approach to industrial yeast strain development		

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Appendix 1 – External presentations and talks

Workshops

Conducted by	Title of workshop	Held	Date
C.A. Simos	Taints and Faults tasting	Fallon and Byrne, Dublin, Ireland	2 Jul 2009
P.J. Smith, I.L. Francis, D.W. Jeffery, T.E. Siebert, D.L. Capone	Wine flavour directions workshop	AWRI Seminar Rooms, Urrbrae, SA	16 Jul 2009
Winemaking and Extension Services team	AWRI Roadshow Workshop: The avoidance of taints and chemical instabilities during winemaking	University of Southern Queensland, Toowoomba, Qld	29 Jul 2009
		The Orange Agricultural Institute Training Centre, Orange, NSW	18 Aug 2009
		Robert Oatley Cellar Door, Mudgee, NSW	20 Aug 2009
	AWRI Roadshow Workshop: A guide to trouble free packaging	Tintara Winery, McLaren Vale, SA	2 Sept 2009
C.A. Simos, E.M.C. Robinson	Flavours faults and taints tasting	Grand Hyatt Hong Kong, Hong Kong	5 Sept 2009
C.A. Simos, E.M.C. Robinson	Taints and contaminations	Regal Hotel, Shanghai, China	9 Sept 2009
Winemaking and Extension Services team	AWRI Roadshow Workshop: The avoidance of taints and chemical instabilities during winemaking	Pettavel Winery, Geelong, Vic	16 Sept 2009
	AWRI Roadshow Workshop: A guide to trouble free packaging	The Valley's Lifestyle Centre Clare Valley, SA	24 Sept and 24 Nov 2009
R. Portolesi, I.L. Francis, P.C. Osidacz	From Grape to Glass : The science of wine, AusBiotech Seminar	AWRI, Urrbrae, SA	28 Sept 2009
Winemaking and Extension Services team	AWRI Roadshow Workshop: A guide to trouble free packaging	Coonawarra Soldiers Memorial Hall, Coonawarra, SA	29 Sept 2009
		Peter Lehmann Wines, Barossa Valley, SA	10–11 Nov 2009
C.A. Simos	Wine flavours, faults and taints tasting	Fallon and Byrne, Dublin, Ireland	1 Feb 2010
	Wine assessment	The Saatchi Gallery, London, UK	3 Feb 2010
	Wine flavours, faults and taints tasting	The Sampler, London, UK	4 Feb 2010
Winemaking and Extension Services team	AWRI Roadshow Workshop: A guide to trouble free packaging for winemakers	Merilba Estate Uralla, New England/Armidale, NSW	19 May 2010

Posters

Author(s)	Title of poster	*Presented at*	*Date*
M. Ugliano, P.A. Henschke	Rapid and accurate determination of hydrogen sulfide in fermenting grape juice using selective gas detector tubes	In Vino Analytica Scientia, Angers, France	2–4 July 2009
M. Ugliano, B. Travis, B. Fedrizzi[1], T.E. Siebert, G. Versini[2], I.L. Francis, P. A. Henschke	The effect of pre-fermentation nitrogen supplementation on the volatile composition and sensory properties of Shiraz wine		
M. Marangon, S.C. Van Sluyter, S.D. Stranks, D. Sutton[3], E.J. Waters, R.I. Menz[3]	Crystallization and preliminary X-ray diffraction studies of four thaumatin-like protein isoforms from *Vitis vinifera* grape juice		
M. Marangon, S. Vincenzi[4], M. Lucchetta[4], A. Curioni[4]	Proteins and tannins of white wine: is hydrophobicity the driving force for their interactions?		

Author(s)	Title of poster	*Presented at*	*Date*
P.J. Chambers, Biosciences Systems Biology Team, and Bioplatform Australia Collaborators	Systems Biology: a new approach to industrial yeast strain development	The 2010th International Conference on Systems Biology, Stanford California, USA	30 Aug–4 Sept 2009
Y. Hayasaka, G.A. Baldock, K.F. Pardon, D.W. Jeffery, M.J. Herderich	HPLC-MS/MS investigations into the formation of potential guaiacol precursors in grape leaves and berries following grapevine exposure to smoke	The 18th International Mass Spectrometry Conference, Bremen, Germany	2–3 Sept 2009
D. Cozzolino, W. Cynkar, R.G. Dambergs, N.K. Shah, P.A. Smith	Applications of near infrared spectroscopy for wine classification and authentication	14th International NIR Conference, Bangkok, Thailand	7–16 Nov 2009
	Measurement of soil vineyard parameters by near infrared spectroscopy		
	In bottle measurements a real tool for the wine industry		
D. Cozzolino, W. Cynkar, R.G. Dambergs, N.K. Shah, M.D. Mercurio, P.A. Smith	Grape tannin measurement by near infrared spectroscopy		
W. Cynkar, G.D. Grayston[5], D. Cozzolino, R.G. Dambergs, N.K. Shah, P.A. Smith	Prediction of grape compositional parameters using a FT-NIR instrument		
H.E. Smyth[6], D. Cozzolino , W.U. Cynkar , R.G. Dambergs, P.A. Smith	Measurement of volatile compounds in wine by near infrared spectroscopy		
N.D.R. Lloyd, M. Ugliano, D. Capone, M. Sefton, D. Taylor[7], G. Elsey[7]	The role of yeast in the generation of the powerful odorant damascenone in wine	4th Australian Conference on Yeast: Products and Discovery 2009, Adelaide, SA	2–4 Dec 2009
G. Winter, M. Ugliano, C.D. Curtin, T. Van Der Westhuizen[8], P. Bowyer[8], P. Henschke, V. Higgins[9]	Regulation of sulfur metabolism during wine fermentation by nutrient supplements		
C.S. Stockley	Can moderate wine consumption really have a significant effect on human health	4th International Conference on Polyphenols and Health in Harrogate, Yorkshire, UK	7–11 Dec 2009
	A role for wine in colorectal cancer		
W.U. Cynkar, D. Cozzolino, N.K. Shah, P.A Smith	Soil measurement in the vineyard: the role of NIR spectroscopy	14th Australian Near Infrared Spectroscopy Conference, Adelaide, SA	19–21 Apr 2010
J. C. Hack, M.D. Mercurio, P. Mercurio	Metabolomics in South Australia	ASMR Annual Scientific Meeting Adelaide, SA	9 Jun 2010
M. Marangon, S.C. Van Sluyter, C. Chan[10], E.J. Waters, R.J. Falconer[10]	The different behaviors of thaumatin-like proteins and chitinases during white wine haze formation	Macrowine, Turin, Italy	16–18 Jun 10
M. Marangon, M. Lucchetta[4], E.J. Waters	Protein stabilisation of white wines using zirconium dioxide enclosed in a metallic cage		

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Appendix 2 – Teaching responsibilities of the AWRI staff during 2009/2010

Semester 2, 2009

Institution	Subject number	Subject name	No of lectures	Staff member
The University of Adelaide	7004WT	Wine packaging and quality management	1	E.J. Waters
	3046WT/7046WT	Fermentation Technology	1	P.A. Henschke
			2	I.L. Francis
			1	J.R. Bellon
	3045WT/7048WT	Advances in Oenology	4	P.A. Henschke
			3	E.J. Bartowsky
			3	M.J. Herderich
			1	C.A. Simos
Flinders University	BTEC 3630	Medical and Molecular Biotechnology	1	S.A. Schmidt
	MMED 3921/ BTEC 9671	Industrial and Pharmaceutical Microbiology/ Bioprocessing and Industrial Biotechnology	1	P.A. Henschke
Melbourne University		Masters of Proteomics and Metabolomics	1	C.D. Curtin

Semester 1, 2010

Institution	Subject number	Subject name	No of lectures	Staff member
The University of Adelaide	3007WT	Stabilisation and Clarification	3	E.J. Waters
			3	A.D. Coulter
	3005WT	Grape Industry Practice, Policy and Communication	6 weeks (subject coordination and 2 lectures presented) Approximately 50 hours	C.S. Stockley
			2	I.S. Pretorius
	2500	Vineyard and Winery Operations II	2	P.R. Dry
	3021	Viticultural Science II	3	P.R. Dry
Universitat Rovira i Virgili, Spain		Masters Program in Oenology and Biotechnology	4	E.J. Waters

Appendix 3 – Student supervision responsibilities of the AWRI staff for 2009/2010

Student	Supervisors	Source of funds
PhD		
A. Carew	D. Close[7], R. Shellie[7], R.G. Dambergs, C.D. Curtin	University of Tasmania, AWRI
D.L. Capone	D.W. Jeffery, M.A. Sefton[5], D.K. Taylor[5]	AWRI
C. Cox	C. Collins[5], P.R. Dry, M. McCarthy[11]	Phylloxera and Grape Industry Board of SA
L. Donchie	J. Jones[7], R.G. Dambergs, C. D. Curtin	University of Tasmania, ICIP, GWRDC
K.A. Dungey	Y. Hayasaka, K. Wilkinson[5], D. Taylor[5]	GWRDC
J. Gill	J. Jones[7], R.G. Dambergs	University of Tasmania, Tasmanian Pinot Forum
J. Hixson	C. D. Curtin, I.L. Francis, S. Bastian[5], I.S. Pretorius	GWRDC
F. Kerslake	J. Jones[7], R.G. Dambergs, D. Close[7]	University of Tasmania, ICIP
E. King	C.D. Curtin, I.L. Francis, I.S. Pretorius, S. Bastian[5]	GWRDC
N.D.R. Lloyd	M. Ugliano, G. Elsey[5], D. Taylor[5]	University of Adelaide
C. McDonnell	P.R. Dry, S. Bastian[5], R. Wample[9]	J. Lohr
S. Nordestgaard	E.J. Waters, C. Colby[4], B.K. O'Neill[5]	APA/GWRDC
T. Tran	P.J. Chambers, G. Stanley[2], M.A. de Barros Lopes[3]	AWRI / Victoria University
S. Van Sluyter	E.J. Waters, F. Pettolino[6], A. Bacic[6]	Melbourne University/AWRI
N. Warnock	S.A. Schmidt, E.J. Waters, P. Anderson[1]	Flinders University/ AWRI/GWRDC
R. Wells	J. Jones [7], R.G. Dambergs, D. Close[7]	University of Tasmania, ICIP
G. Winter	M. Ugliano, C.D. Curtin, V. Higgins[8]	University Western Sydney, AWRI
C. Yonker	C. Ford, P.R. Dry, S. Bastian[5], N. Dokoozlian[10]	E&J Gallo

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Theses completed

Student	Hon/PhD	Title of Thesis	Supervisors
E. Cooter	Hons	Gasification of winery waste products for the production of renewable energy	R. Muhlack, P. Ashman[1], P. van Eyk[1]
A.P. Haria	Hons	Measuring the effect of mixed yeast ferments in wine using rapid spectroscopic methods	D. Cozzolino, C.D. Curtin, M.A. de Barros Lopes[2]
S. Holt	Masters	Developing carbon sulfur beta-lyases active at low pH	C.D. Curtin, P. Anderson[3], J.H. Swiegers[4], J. Winther[5]

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Appendix 4 – Media interviews during 2009/2010

Date	Staff member	Discussed	Media
7 Jul 2009	I.L. Francis	Wine tasting and language	Sam de Brito, Fairfax Digital
9 Jul 2009	T.E. Siebert	Black pepper character in Adelaide Hills Shiraz	Tony Love, *The Advertiser*
24 Jul 2009	D.L. Capone	Eucalyptol in Australian red wines	Nick Bulleid, *WBM*
27 Jul 2009	D.W. Jeffery	Pepper character in Australian Shiraz	Nikolai Beilharz, ABC Radio
31 Jul 2009	B. Travis	Tasting of Tokay style wines at the AWRI	Lauren Jones, *Australian and New Zealand Wine Industry Journal*
7 Aug 2009	A.D. Coulter	Use of sulfur dioxide in organic winemaking	*Australian Natural Health* magazine (published #5 Vol 9)
24 Aug 2009	C.S. Stockley	Potential health benefits of moderate wine consumption, such as cardiovascular disease and cancer	Paula Goodyear, *Sydney Morning Herald*
27 Aug 2009	M. Essling	Research to Practice	Lauren Jones, *Australian Viticulture*
10 Sept 2009	I.S. Pretorius	The future use of GMOs in the wine industry – potential opportunities and risks	Amelia Genia, *Farmers Weekly*, South Africa
18 Sept 2009	I.L. Francis	Expert machines	Ben Crystall, *New Scientist*, UK
23 Sept 2009	A.D. Coulter	Use of sulfur dioxide in winemaking	ABC Rural Radio
	R.A. Muhlack	Renewable energy from winery biomass waste	ABC Rural Radio (*SA Country Hour*)
25 Sept 2009	C.A. Simos	Advanced Wine Assessment Course and Institute of Masters of Wine co-operation	Tim White, *Australian Financial Review*
28 Sept 2009	I.L. Francis	Effect of bubbles on Champagne flavour	Dani Cooper, ABC Science on-line
29 Sept 2009			Emma Tonkin and Garth Russell, ABC radio Newcastle
30 Sept 2009			Grant Cameron, ABC radio Adelaide
5 Oct 2009	R.G. Dambergs	Sparkling wine research in Tasmania	Mark Smith, *Australian Viticulture*
			Clare Van Ryn, *The Examiner*, Launceston
		Pinot Noir research in Tasmania	Mark Smith, *Australian and New Zealand Wine Industry Journal*
1 Dec 2009	M.J. Herderich and D.W. Jeffery	Understanding thiol precursor factors	Malcolm Sutton, *Australia and New Zealand Grapegrower and Winemaker*
16 Dec 2009	E.J. Bartowsky	Wine Excellence feature and 'People in Research' feature	Malcolm Sutton, *Australia and New Zealand Grapegrower and Winemaker*
Jan 2009	R.G. Dambergs	Pinot Noir research in Tasmania	Rosemary Grant, ABC Rural Report
8 Feb 2010	C.S. Stockley	Potential health benefits of wine consumption	Jeremy Oliver
12 Feb 2010			*Natural Solutions Magazine* (USA)
18 Mar 2010	J.A. Kennedy	Suitability of grape-derived phenolic compounds for determining wine varietal authenticity	*Chemical and Engineering News* (published 4 Apr 2010)
8 Apr 2010	D.W. Jeffery	Wine flavour compounds such as rotundone, thiols and cineole; importance of yeasts to wine flavour	Julianna Kadar, *Cosmos Magazine* (online 22 Apr 10)
26 May 2010	C.S. Stockley	Resveratrol in the prevention of bowel cancer	Jenni Port, *Melbourne Age*
9 Jun 2010	I.S. Pretorius	The AWRI; how it works; how it contributes to the Australian wine industry; and how the Australian wine industry is different to other industries because of the AWRI	Remke de Lange, Freelance Dutch journalist
25 Jun 2010	R.G. Dambergs	Flextank project	Megan McNaught, *Hobart Mercury*

Appendix 5 - Papers published by the AWRI staff during 2009/2010

1134 Fedrizzi, B., Pardon, K.H., Sefton, M.A., Elsey, G.M., Jeffery, D.W. First identification of 4-*S*-glutathionyl-4-methylpentan-2-one, a potential precursor of 4-mercapto-4-methylpentan-2-one, in Sauvignon Blanc juice. J. Agric. Food Chem. 57(3), 991–995; 2009.

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Appendix 5 – Papers published by the AWRI staff during 2009/2010

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88 Carlo Congiusta
89 Anne Lord
90 Phil Mercurio
91 Ella Robinson
92 Sally-Jean Bell
93 Helen Holt
94 Randell Taylor
95 Jason Geue
96 Gayle Baldock

Absent

Caroline Abrahamse
Ingrid Barratt
Kate Beames
Jenny Bellon
Francesca Blefari
Catherine Borneman
Guus Classens
Adrian Coulter
Alfons Cuijvers
Chris Curtin
Bob Dambergs
Shiralee Dodd
Peter Dry
Robyn Gleeson
Amy Hill
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Stella Kassara
Robyn Kievit
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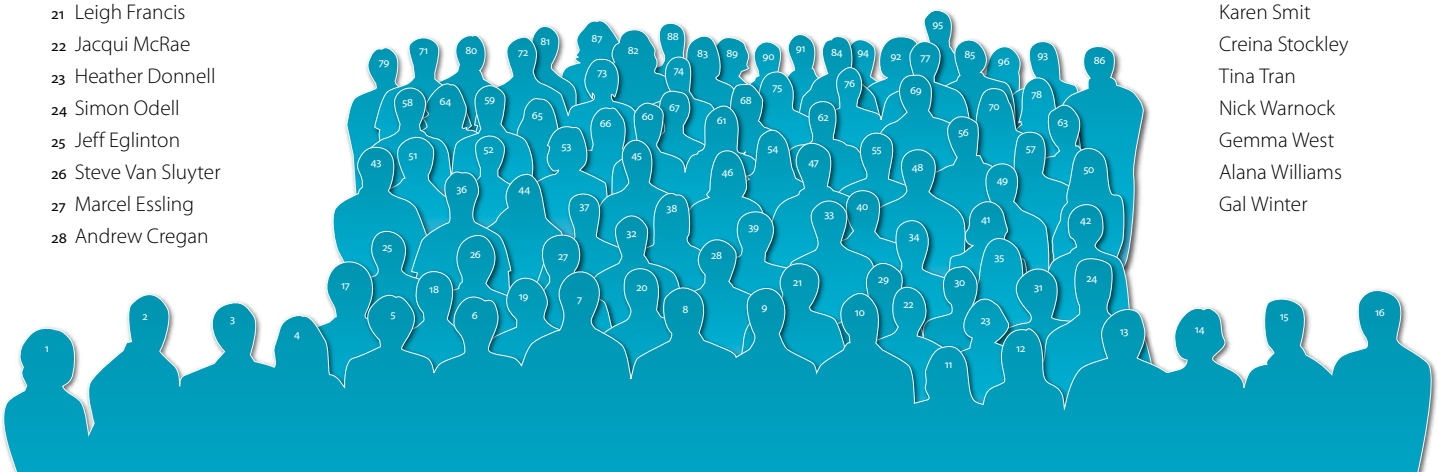
Gal Winter



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