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WINE & VITICULTURE JOURNAL

WINTER

- Vegan-based winemaking products - what's in the arsenal?
- Effect of sparging on the composition of white wines
- Dormancy and cold-hardiness - two sides of the same coin?
- The opportunities and challenges of growing wine sales in India
- Tasting: Gruner Veltliner

WINE & VITICULTURE JOURNAL

INDUSTRY ASSOCIATION COLUMNS

WINEMAKING

VITICULTURE

BUSINESS & MARKETING

VARIETAL REPORT

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Sonya Logan, ***Editor***

As strong winds, rain, grey skies and a chilly 13.9°C (feels like 9.0°C according to my weather app!) prevail outside the Winetitles Media offices in Adelaide, there couldn't be a more fitting backdrop to writing this introduction to the Winter issue of the *Wine & Viticulture Journal*.

If the front is any indication of the weather likely for 26-29 June when the Australian Wine Industry Technical Conference and WineTech trade exhibition will be taking place in Adelaide, it's going to be a wild and woolly walk along North Terrace to reach the Convention Centre. With more than a thousand delegates expected to attend the conference, perhaps a walking school bus-like formation could be organised to help shield the collective from the elements! Just a thought.

At the time of writing in late May, the representative from the South Australian Government tasked with the job of formally opening the AWITC was yet to be announced due to the fact that the newly-elected Labor Government was still bedding in following the 19 March election. Perhaps Mali himself — as Premier Peter Malinauskas is known in local political circles — might assume the gig. Would be a good opportunity for Mali to publicly demonstrate his support of the industry that is the third biggest generator of revenue among the state's primary industries and agribusiness sector.

Whatever the weather and welcome, I am looking forward to talking face-to-face with as many members of the industry as possible after a protracted period of screen-meets.

This issue of the *WVJ* more than adequately whets your appetite for all things technical and business related. The highlights include...

In Winemaking, Rachael Gore walks readers through new and innovative vegan-friendly wine additives that are now available (page 12), while a team of researchers from the Australian Wine Research Institute, Treasury Wine Estates and Wine Australia present the results from a study that compared the effects of cold setting and flotation on the composition, taste and texture of Chardonnay and Frontignac wines (page 16).

Bit of a disease focus in Viticulture, beginning with a report by Mark Sosnowski and Matthew Ayers from the South Australian Research and Development Institute (SARDI) who have shown from their Adelaide Hills trials that the timing of winter pruning influences the susceptibility of wounds to infection by grapevine trunk disease pathogens. Their work has highlighted the importance of localised research into wound susceptibility to trunk pathogen species in Australian wine regions (page 35).

And, in Business & Marketing, Justin Cohen from the University of South Australia weighs in on how Australian wine exporters can take advantage of the opportunity presented by the Australia-India Economic Cooperation and Trade Agreement and addresses some of the challenges of the Indian market (page 67).

Finally, coverage of our recent Gruner Veltliner tasting can be found on page 80. I think this Austrian may just be my new favourite alternative variety!. .

Cover image: Wine Australia

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REGULAR FEATURES

(ADVERTORIAL)

Colliers Market Update

AUSTRALIA

The Australian wine industry is confronting several headwinds: firstly, from the need to find replacement markets for the large volume of red wine previously destined for China and, secondly, high export costs and disruptions to shipping. These events affect wine industry participants differently, creating opportunities, particularly in the warm climate regions which service larger producers. New free trade agreements with the UK and India have helped to establish new markets.

Demand for significant assets in the cooler temperate regions has remained strong and the demand for high end Pinot Noir has never been better with farmgate prices supporting greenfield vineyard developments in the Yarra Valley, Tasmania and Adelaide Hills in particular.

Recent Australian highlights include the sale of Tasmania's Josef Chromy Wines to a partnership between Endeavour Group and Warakirri Asset Management for $55 million. Current campaigns of premium McLaren Vale, Yarra Valley and Adelaide Hills vineyards have generated significant buyer demand at prices well above $100,000 per hectare. Colliers has been appointed by Casella to find a strategic partner to own and operate a selection of its vineyard holdings across 35 properties in South Australia and New South Wales, making it the largest vineyard transaction in Australia.

NEW ZEALAND

The 2022 harvest in New Zealand is now complete. Final production figures are yet to be published but anecdotal evidence suggests a very large crop, particularly in Marlborough which accounts for 75-80% of New Zealand's production. This will enable wine companies to meet previously stretched supply shortages due to strong international demand and a lower-than-average 2021 vintage. The contract grape price has increased over the last few years in most regions resulting in favourable returns to growers, although tempered by industry issues including labour shortages and increased operating expenses.

Smaller wineries have recently been impacted by the decline in hospitality and cellar door trade. It is expected that these smaller wineries will start to see increased foot traffic with the staged reopening of the international border, albeit at lower levels compared to pre-COVID-19.

Overall, underlying industry confidence remains positive with strong grower and winery relationships. We have seen strong growth in the wine industry with increased vineyard production and processing capacity, stronger demand from export markets and a lift in the contract grape price paid to growers. This has resulted in vineyard values increasing with an active property market at the current time.

WINE EXPORTS

AUSTRALIA-INDIA TRADE AGREEMENT TO BOOST OPPORTUNITIES FOR WINE EXPORTERS

Australian Grape and Wine (AGW) and Wine Australia have welcomed the April announcement that the Australian and Indian governments have signed the Australia–India Economic Cooperation and Trade Agreement (AI ECTA).

When the AI ECTA enters into force, preferential tariff treatment will be afforded to premium Australian wine exported to India, making Australia the first major wine producing country to negotiate such arrangements. India has also agreed to extend any preferential arrangements for wine afforded to other trading partners in future to Australian wine.

"This agreement is a positive first step in our sector's market-diversification agenda as we seek to recover from the loss of the market in China," said Tony Battaglene, chief executive of AGW, adding that it was particularly beneficial for "very high-value wine producers, many of which are small and medium-sized businesses".

"They will now have confidence to explore new opportunities in the Indian market as the staged tariff reductions are implemented," Battaglene said.

Wine Australia general manager corporate affairs and regulation Rachel Triggs said, "There is potential for growth in the sale and consumption of Australian wine in India with Australia already having the greatest share of the imported wine market.

"The wine culture in India is maturing as consumers discover and learn more about wine. It's exciting to contemplate Australian winemakers playing a role in that maturation, and the AI ECTA will make it easier for them to do so," Triggs said.

In the 12 months to the end of December 2021, Australian wine exports to India increased by 81 per cent in value to $12 million – a record value of Australian wine exports to India. Volume also increased by 71% to 2.5 million litres, with 74% of this volume being red wine.

The common customs tariff on wine imported to India is 150%, making it a challenging market for imported wine.

AUSTRALIA AND CHINA WTO DISPUTE RESOLUTION ADVANCES

The appointment of panellists to adjudicate Australia's challenge to the anti-dumping duties imposed on Australian bottled wine by China at the World Trade Organization has been welcomed by Australian Grape & Wine (AGW).

"This is the next step in the WTO's dispute resolution process," said Tony Battaglene, chief executive of AGW. "We were pleased by the cooperation between Chinese and Australian officials in moving quickly through this phase. We also understand that agreement was reached between Australia and China on the forward appeals process, in the absence of a functioning WTO Appellate Body, which is also positive.

"We understand that submissions will now be presented to the panel before a formal hearing later this year. We look forward to demonstrating to the world that Australia produces great wine and does so in a fair and transparent manner," Battaglene said, adding that the wine industry remained open to further discussions with China about how the issue can be resolved.

"The anti-dumping duties on Australian bottled wine have effectively stopped Australia's wine trade with China, to the detriment of our producers, Chinese consumers and Chinese owned businesses that relied on the trade," he said.

UK WINE TRADE WELCOMES RETURN OF AUSTRALIA TRADE TASTING

The Australia Trade Tasting returned to London on 7 April 2022, marking Wine Australia's first in-person event in the UK since COVID-19 and the signing of the historic Australia-UK free trade agreement (FTA).

Featuring 54 exhibitor tables, the wine tasting featured more than 700 Australian wines from 170 producers.

"We're super excited to have kicked off our first in-person event in the UK after a two-year hiatus. And in addition to showcasing our usual favourites, it was great to see 100 wines from new producers seeking distribution in market," said Wine Australia chief executive Martin Cole.

Wine Australia's regional general manager of the UK and Europe, Laura Jewell, said, "There was a fantastic atmosphere at the Australia Trade Tasting, with a lot of energy and enthusiasm, and it was great to see guests discovering new wines and renewing old acquaintances. The tasting was a much-needed opportunity for trade to get up-to-date on Australian wine and catch up with distributors."

WINEGRAPE PRICING

$989K GRANT TO IMPROVE WINEGRAPE PRICE TRANSPARENCY

The Australian grape and wine sector has secured a $989,000 grant from the Australian Government to build an online winegrape price indicator platform aimed at improving market transparency and informing business decision-making.

Once developed, the platform will give winegrape growers access to timely and accurate pricing information so they can better understand the market.

A consortium comprising Australian Grape & Wine (AGW), the Inland Wine Regions Alliance (IWRA) and Wine Australia secured the funding through the Australian Government's Improving Market Transparency in Perishable Agricultural Good Industries initiative, and will jointly oversee the project, with Wine Australia as the lead agency.

"This grant is a huge win for the Australian grape and wine sector and a testament to the collaboration and cooperation between the members of the consortium," said Wine Australia's chief executive Martin Cole.

"The sector is going through an incredibly challenging period, hit hard by COVID-19, labour shortages, China tariffs, global shipping issues and the annual challenges with a changing climate.

"The three organisations all have the same goal of improving efficiency, sustainability and profitability for the sector, and we've worked together to develop the project concept and ensure it meets the needs of our various stakeholders," Cole said.

In addition to the platform, the project will establish a dataset of domestic wholesale sales figures based on collecting transactional data from wineries. This will align with the export dataset maintained by Wine Australia and allow a comprehensive picture to be provided of total Australian wine sales.

Tony Battaglene, chief executive of AGW, said the project would fill a crucial gap in information currently available to the sector, and would provide wineries and growers with valuable insights into how the market is performing.

"The domestic market is by far the largest single market for Australian wine, accounting for over 40 per cent of production. Identifying trends and indicators in this market is a very important part of understanding the overall picture of supply and demand," Battaglene said.

A third component of the project will be to facilitate the use of the price indicator data by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) in order to publish independent winegrape price forecasts for commercial grapes.

"We will build a strategic partnership that will enable the wine sector to leverage ABARES' considerable resources and economic expertise in the field of agricultural forecasting and obtain a broader perspective on grape pricing," Cole said.

"A significant value-add for the project will be the ongoing preparation of commercial winegrape price forecasts by ABARES as part of their normal activities."

The project is expected to commence in July 2022 and be completed within three years.

INDUSTRY ORGANISATIONS

WINE AUSTRALIA WELCOMES NEW MARKETING GM

Paul Turale has been appointed Wine Australia's general manager of marketing.

He joins Wine Australia from leading food packaging business Detmold Group, where he was general manager of business development, specialised products.

He has more than 20 years' experience in the wine sector and has held leadership positions at multi-national listed corporate wine businesses and medium to large private wine companies, including Casella Family Brands/Peter Lehmann Wines; Orlando Wines/Jacob's Creek and Pernod Ricard.

"Paul will be responsible for the strategic leadership of Wine Australia's marketing team, working closely with the entire Australian grape and wine sector to drive market development, open new markets and increase the demand and premium paid for all Australian wine," said Wine Australia's chief executive Martin Cole.

NEW ZEALAND

NZ WINE INDUSTRY WELCOMES UK FREE TRADE AGREEMENT

The signing of a historic free trade deal between New Zealand and the United Kingdom has been welcomed by New Zealand Winegrowers (NZW).

"The agreement is very positive for the New Zealand wine industry," said Philip Gregan, chief executive of NZW. "This will help remove technical barriers to trade and minimise burdens from certification and labelling requirements. It will also support future growth in the market, and encourage exporters to focus on the UK.

"The UK is New Zealand's second largest export market for wine, with exports valued at over $400 million over the past 12 months. The agreement will reduce trade barriers on New Zealand wine exports to the UK, which will make a big difference for many within our industry," Gregan said.

EVENTS

PACKWINE RETURNS IN 2022 TO HIGHLIGHT THE YEAR'S BEST PACKAGING INNOVATIONS

After the enormous success of last year's inaugural event, PACKWINE is back in 2022 to share the latest trends and innovations to enhance Australian and New Zealand wine products.

Presented by the wine industry's leading publisher Winetitles Media, the 2022 PACKWINE Forum & Expo will again deliver expert industry speakers, an expo to feature top wine packaging suppliers and an awards presentation to celebrate the year's best packaging designs.

With packaging remaining a critical factor in the success of wine branding and sales, PACKWINE 2022 will be an essential event for all wine professionals wanting to stay at the cutting edge of the industry.

Presented as a virtual event, PACKWINE will be published in the September 2022 issue of the *Australian & New Zealand Grapegrower & Winemaker*, sister publication to the *Wine & Viticulture Journal*, with digital content also being published online.

Building on the strong industry involvement in last year's webinar, PACKWINE will again draw leading specialists in wine packaging and design to present their insights into new technologies, products, services, marketing and more.

Industry and digital event 'goers' will also have the opportunity to network with leading packaging and design suppliers whose state-of-the-art products and services will be displayed at the 2022 PACKWINE Expo.

Now in their second year, the PACKWINE Design Awards will celebrate 2022's very best packaging innovations, with winners across six categories selected by a panel of industry experts. The highly popular PACKWINE People's Choice award also returns in 2022.

The awards are open to all wines from an Australian and New Zealand appellation, as long as they're commercially available to the general public in 2021 or 2022.

Designs will be judged on the criteria of initial impact, target market effectiveness and overall aesthetics.

An expert panel of wine industry judges will assess all the entries and determine which designs have excelled and deserve top honours for each category, while the People's Choice award will recognise the most popular design entry across all categories.

More information about the coming event and how to enter the awards can be found online: www.packwine.com.au

The new deal: marketing initiatives for the next year

By Tony Battaglene, Chief Executive, Australian Grape and Wine Incorporated

On 23 December 2020, the Australian Government announced an investment of $85.9 million to help Australian agribusinesses expand and diversify their export markets through the Agri-Business Expansion Initiative (ABEI). ABEI includes grants for market expansion, in-country engagement activities, accelerated work on technical market access and greater collection and delivery of market intelligence to exporters. A fifth element is being delivered by Austrade and involves scaling-up its business support services to assist more than 2000 agri-food exporters each year.

In June 2021, Australian Grape & Wine was awarded a $998,000 grant designed to assist the sector's effort to withstand the impact of China's decision to impost prohibitive anti-dumping duties on Australian bottled wine in March that same year. The effective closure of the $1.2 billion China market has resulted in impacts being felt by the whole grape and wine sector, including those businesses that do not export. The only way we can begin to mitigate these impacts is to grow demand elsewhere and this grant will support the sector to do this.

This initial investment involved:

- development of a high-level sector framework to deliver growth through market diversification in the Australia grape and wine sector
- establishment of two in-market consumer and trade focused Australian wine ambassadors, one in Japan and one in South Korea
- development of a detailed trade and market access strategy and associated action plan that targets removal of barriers to trade to reduce time and cost imposts on the sector's exports
- creation of a United States wine market access tool that will provide small and medium Australian wine businesses with a greater understanding of differing requirements across all 50 states and provide information supporting the businesses to develop strategies to enter the market.

Following the successful progress of the first grant, on 4 April 2022, the Australian Government awarded a further $1,817,000 grant to Australian Grape & Wine aimed at continuing to improve trade and grow demand in diversified international markets for Australian wine.

The stage two funds will be used to ensure the longevity of the ambassador roles into 2024 and expand the in-market activities of these existing roles. They will also be used to employ an additional role to focus on Scandinavian markets. All these positions provide the opportunity for a greater understanding of consumer trends by Australian wine exporters.

These funds are an additional government boost to industry levies paid to Wine Australia to deliver marketing on behalf of the Australian wine sector. Strategy and coordination of industry engagement within these roles will be provided by Australian Grape & Wine with activities governed by a joint steering committee and joint marketing advisory committee with Wine Australia. Wine Australia will also play a key role in managing the operational administration of the ambassador roles. Just over 60% of the total grant funding provided will be utilised to support the marketing and promotion pillar into 2024.

The second pillar supports a broad range of activities established under a trade and market access strategy and an action plan developed in Stage 1. This includes a range of collaborative technical and regulatory initiatives aimed at efforts to mitigate trade barrier risks, streamline aspects of trade in key markets to reduce cost and time imposts and support greater regulatory cooperation. Areas of activity include:

- supporting the establishment of ongoing regulatory forums with key markets (building on the highly successful APEC Wine Regulatory Forums)
- development of systems to assist with monitoring, tracking and reporting of trade barrier information
- expansion of laboratory proficiency testing and work on harmonisation of testing methods
- assessment and the development of a report on key sustainability trends (consumer, customer and regulatory) in major wine markets
- work with international wine retailers in support of recognition of the Australian wine sector's sustainability credentials (including reducing market impediments in the Canadian and Scandinavian monopolies)
- further investment in the US wine market tool to continuously improve its value for the sector
- supporting technical exchange and cooperative efforts across key international forums such as the World Trade Organization, Codex Alimentarius, APEC, OIV and World Wine Trade Group.

The activities under this pillar will be initiated during 2022 and will continue into 2024, utilising just under 30% of the total grant funding.

Building on the recently announced trade agreement between Australia and India, the third key pillar involves activity aimed at supporting technical exchange and regulatory cooperation on wine between the two countries. It will involve both industry and government regulatory engagement in efforts to further cooperation on wine and improve trade in wine beyond the outcomes of the FTA.

It will allow Australian Grape & Wine the resourcing to initiate its long-term strategy for India involving:

- key stakeholder mapping exercise of major players and their role in wine production in India
- work on establishing the practice of bilateral meetings in the margins of international forums of shared membership
- building technical expertise in India – business to business
- building technical expertise in India – regulator to regulator
- explore options to use wine as a driver of deeper bilateral engagement between Australia and India across business, culture and sport.

These activities will utilise the remaining 10% of the available grant funds during 2022 to 2024 and will be continued beyond the completion of this grant funding in line with the longer-term India strategy.

MORE INFORMATION

For more information on the project and its outcomes for the sector visit Australian Grape & Wine's 'Growing our exports' page: https://www.agw.org.au/policy-and-issues/growing-our-exports/ WVJ

New guide to help grapegrowers reduce the risk from biosecurity threats

By Dr Liz Waters, General Manager Research, Development and Adoption, Wine Australia

It can at times feel that Australian winegrape growing and wine production faces an ever-growing list of pests and diseases that threaten the future of vineyards and the productivity of our sector.

From *Xylella fastidiosa*, spotted lanternfly, grapevine phylloxera, grapevine red blotch virus to brown marmorated stink bug – these serious pest and disease threats all have the potential to cause vine death, restrict vine growth, impact berry quality and quantity and increase production costs.

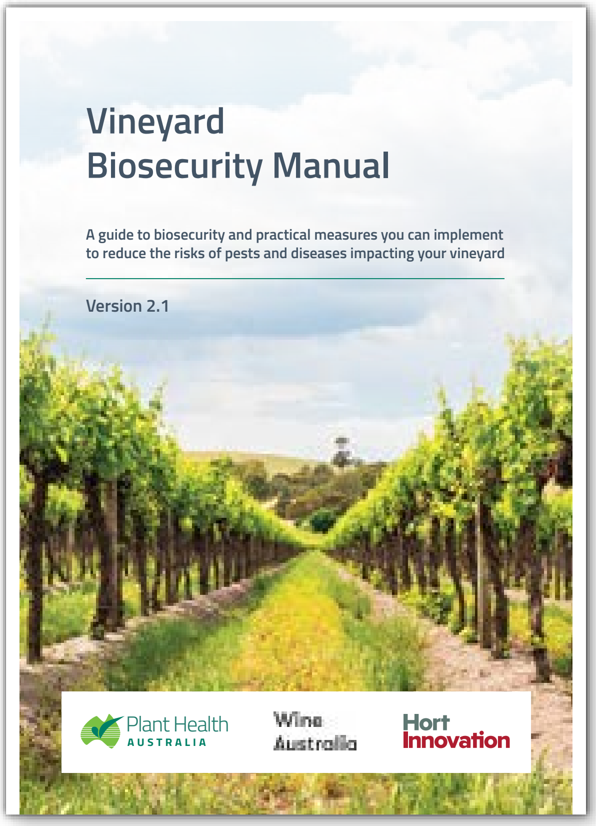
Biosecurity plays a vital role in protecting our vineyards and industry, both now and for its future, by preventing incursions into vineyards and along the production chain as well as preparing contingency plans for the effects of outbreaks.

Australian vineyard managers and those who supply or work on vineyards now have a new tool at their disposal to help resist the threats posed by pests and diseases with the release of the 'Viticulture Biosecurity Manual'.

The manual, developed by Plant Health Australia in collaboration with Wine Australia, Australian Grape & Wine, Vinehealth Australia, Hort Innovation, Australian Table Grape Association and Dried Fruit Australia, guides vineyard managers through the process of understanding what biosecurity risks threaten their property and supply chain, where to find information and support, and what steps they can take to reduce risks.

Taking steps to secure your property and know what is coming in and then detecting and responding to pests and diseases early is better than trying to take action after a biosecurity disaster occurs.

The 'Viticulture Biosecurity Manual' provides a step-by-step guide to identify how pests and diseases may come into a vineyard or the supply chain and the biosecurity measures that can reduce that risk.



The manual...guides vineyard managers through the process of understanding what biosecurity risks threaten their property and supply chain, where to find information and support and what steps they can take to reduce risks.

People, vehicles, plant material and equipment like pruning equipment, pallets and storage bins can all bring in pests and diseases, so strong biosecurity — including monitoring for early signs of pests and diseases and responding quickly — can save time and financial losses. The impact of an outbreak shouldn't be underestimated. Even a small, localised event can be devastating for those affected, taking both an emotional and financial toll from the disruption it can cause. Every person who works in our sector must share the load to protect it.

Within biosecurity it's often said that 'a rising tide lifts all boats', reflecting the importance of a cooperative effort. Pests and diseases don't respect property boundaries and do not care whether grapes are being grown for wine or the table. To provide the maximum protection for the wine sector we need to work closely with each other and our neighbours and colleagues in other agricultural industries, including those who grow table grapes and produce dried fruits, as we face some common threats and need to have common approaches to biosecurity planning and managing pests and diseases.

We'll be using this biosecurity manual as a base to build more detailed information and combine it with existing material to provide a strong resource for winegrape growers and those who work within our sector.

The 'Viticulture Biosecurity Manual' is available to freely download at www.planthealthaustralia.com.au/industries/wine-grapes WVJ

ASVO membership discount for AWITC delegates

By Brooke Howell, President, Australian Society of Viticulture & Oenology

MEMBER DISCOUNT WHEN COMBINING WITH AWITC REGISTRATION

The 18th Australian Wine Industry Technical Conference is just days away (26-29 June 2022). As a partner of the AWITC, the Australian Society of Viticulture & Oenology is offering a 30% discount off new or existing full fee membership renewals to those who have registered to attend the event. To have the discount applied, visit the ASVO website and enter your AWITC invoice or registration number to receive a discount coupon code (www.asvo.com.au/awitc-and-asvo-membership-offer).

NOMINATIONS OPEN FOR ASVO FELLOWS

Each year the ASVO board elects Fellows of the society from members who have made a particularly outstanding and meritorious contribution to the grape and wine industry. The criteria for this honour include making a **major contribution in an industry, scientific,** educational or society role combined with membership of the society for at least 10 years. The ASVO Fellows who have been recognised to date represent the practitioners, researchers, teachers, entrepreneurs, consultants, mentors and leaders of our Australian wine community.

The ASVO board looks to society members to identify and nominate their peers that have made an exceptional contribution to the industry and the society over the course of their careers. If you know an ASVO member who has made a particularly outstanding and meritorious contribution to the grape and wine industry and is worthy of recognition for their exemplary contribution to the society, please nominate them for consideration as an ASVO Fellow. Nominations to be considered in 2022 close on Sunday 31 July 2022. Please refer to the eligibility criteria when preparing your nomination. Nominations can be submitted throughout the year, online through the ASVO website (www.asvo.com.au/nomination-fellow-society).

10TH ANNIVERSARY OF THE AWARDS FOR EXCELLENCE

The ASVO will proudly present its Awards for Excellence for the tenth year in 2022. This year the event will be held in person at the National Wine Centre on Wednesday 16 November and live streamed to key venues around Australia. We are excited to be introducing a new award category, Wine Science and Technology, alongside the Viticulturist and Winemaker of the Year. We will also be announcing the Viticulture and Oenology Papers of the Year and the Dr Peter May award for the most cited paper from the *Australian Journal of Grape and Wine Research* in the previous five years. With the last two years being streamed online, we are looking forward to welcoming our members back to a live event and providing networking opportunities.

VIDEO LIBRARY

The ASVO has worked hard to record individual presentations from our recent seminars in the last few years. These presentations are an invaluable source of information on the latest research and case studies from practitioners. Whether you missed the seminar or attended but want a refresher, these videos are available exclusively to members on the ASVO website.

PODCASTS

The ASVO has started a podcast called Grower, Maker, Researcher where we will be calling on members to discuss the latest research and how it is being applied in practice. There are three podcasts available on yield estimation, irrigation efficiency and the applicability of Wine Australia's recently released Climate Atlas. Search for Grower, Maker, Researcher on Apple Podcasts, Google Podcasts and PodBean.

Vegan-based winemaking products
What's in the arsenal?

By Rachel Gore, Director, Free Run Consulting Email: rgore@freerunconsulting.com.au

In response to rising demand for vegan-friendly wine, a number of new fining agents are now available as substitutes for traditional animal-based products. Rachel compares these alternatives.

Based on data from the National Nutrition Survey and other studies, it is estimated that about 2% of Australians are vegan. This equates to approximately 500,000 people.

A vegan is someone who actively strives to bring about a world where animals are not used by humans for food, clothing, entertainment or any other purpose. Vegans put this into practice in their daily lives by eating a diet consisting of fruits, vegetables, beans, grains, nuts, seeds and other plant foods and by not wearing or using any animal products.

Consumer interest in vegan wines is growing, with vegan-friendly wines showing up in many supermarkets and Google searches for 'vegan wine' soaring in recent years.

But what makes a vegan-friendly wine and how is it different to a conventional wine?

Given that wine is the product of grapes and yeast, some may assume that all wines would be appropriate for vegans — but this isn't always the case.

In conventional winemaking, for both red and white wines, the grape has a long pathway from vineyard to bottle. Red wine fermentation involves time on skins to extract and enhance anthocyanins. Additions and manipulations during this phase are common and can involve the addition of nitrogen in numerous forms to 'feed' the yeast and ensure that the ferment is both controlled and goes to completion. Enzymes may be added, either to break down pectin, improve settling or to enhance flavour. Secondary fermentation or malolactic fermentation can be either inoculated for or allowed to go through naturally but perhaps the period of highest intervention is prior to bottling during the process known as 'finishing the wine'.

Wines are routinely tasted prior to bottling — batches are blended and varieties are sometimes integrated. At this stage a decision is often made that a young wine may need adjustment for either colour, palate structure or aromatic intensity. Winemakers will often add one or more of the permitted additives after setting up tasting trials to assess the impact of the type and rate of different products — a process known as 'fining'.

Before getting into the reason why we fine, perhaps we should look at the process…

Freshly pressed grape juice contains pressed seeds, stems and skins that can all make their way through the press into wine, often producing bitter and astringent sediment.

Filtration can be used to remove some unwanted sediment but only the fining process can remove compounds that are too small to be caught by a filter, such as tannins, phenols and proteins. Fining agents are traditionally applied during wine production to obtain a brighter and more clarified product as a result of the elimination of particles responsible for turbidity. These agents are also beneficial to soften tannin intensity, improve the perception of mouthfeel and to improve wine filterability and stabilisation.

This is where things get problematic for vegans or consumers with intolerances.

The commonly used proteins for fining are historically made from one of four kinds of animal protein:

- gelatine sourced from cow or pig collagen
- egg whites
- isinglass from fish bladders
- skim milk and/or casein.

Although these fining agents seem to have a high efficacy for wine stabilisation and clarification when added to must or fermented wine, some of these may be ethically unacceptable or cause potentially harmful adverse bodily reactions. This latter fact raises concerns for the average consumer since there is a risk of food intolerances and allergic reactions, leading consumers to be more thoughtful about what they consume.

Each of these different fining agents target different substances, so it is crucial that the winemaker knows the issue or problem in order to select the correct fining agent necessary.

There are now a number of new and innovative wine additives that are vegan friendly and often perform better than their animal protein cousins so let's take a look at the comparisons.

PEA PROTEIN (VEGAN FRIENDLY) VS CASEIN (ANIMAL PROTEIN)

Pea proteins are allergen-free, plant-based proteins designed to combat oxidation of juice and wine while contributing to a wine's clarification. Pea proteins can improve the organoleptic properties of wine, removing aggressive tannins and bitterness to produce a softer, rounder palate with enhanced aromatic freshness.

Casein is the principal protein in milk and is used mainly in the clarification of white wines to reduce the level of phenolic compounds

IN BRIEF

- **Consumer interest in vegan-friendly wines is growing.**
- **As a product of grapes and yeast, some consumers might assume that all wines are vegan-friendly but this isn't always the case.**
- **The area of winemaking that is most problematic for vegans is fining; the agents commonly used in fining are historically made from animal proteins.**
- **A number of new and innovative wine additives that are vegan friendly are now available and often perform better than their animal protein counterparts.**

associated with bitterness and browning. Whilst it is softer on wine than gelatine or isinglass, it is known to have limited clarifying action. Its drawbacks include colour stripping if excessive amounts are used, and it requires a second fining with bentonite if wine is to be filtered.

YEAST PROTEIN EXTRACTS VS ISINGLASS

Today, yeast extends its benefits to the process of fining wines. Depending on the production method of yeast protein extracts, they can be categorised into distinct types: inactive yeasts (obtained by thermal inactivation and drying of the yeasts), yeast autolysates (thermal inactivation followed by an incubation step allowing enzymatic activities and cell wall degradation), yeast hulls or walls (yeast walls without cytoplasmic content), and yeast extracts (the soluble extract of the cytoplasmic content after elimination of the cell walls) (Pozo-Bayon *et al*. 2009).

Yeast protein extracts obtained from wine and grape endogenous yeasts are potential alternatives to animal-derived fining agents. Yeast protein extracts can be obtained from distinct components of yeasts, including the cytoplasm, vacuole or the cell wall, and are applied during the winemaking process with different purposes. Due to the molecular weights and specific charges on protein yeast extracts, they are excellent at flocculating (the process by which individual particles aggregate into clot-like masses or precipitate into small clumps) with colloidal matter in wine, aiding in clarification and stabilisation.

Isinglass, derived from the air bladder of fish, is an effective, positively charged fining agent most often used as the very last step in clarifying wine before bottling. It is most effective in clarifying white wines, particularly oak-aged whites, and is especially adept at removing harshness and astringency due to its activity of removing polyphenolic compounds. As with casein, it requires a second fining with bentonite if wine is to be filtered.

POTATO PROTEIN VS FINING GELATINE

The use of plant-derived proteins as wine fining agents are gaining interest. Patatin P is the name of a family of glycoproteins that can be recovered from potato by-product. These glycoproteins make up more than 40% of the total soluble protein in potato tubers. Tuber proteins are present in water from potato processing so the use of these wastes as by-products for further use is economically attractive.

Whilst traditional animal-based fining agents reduce wine astringency, the potato-derived protein Patatin P has a molecular mass similar to that of egg white and a low solubility at wine pH indicating that potato protein may be an important vegetable alternative for wine fining.

Gelatine has been used for the clarification or fining of wine since the Roman civilisation and probably well before that.

Derived from hooved animals, gelatine is most often used to reduce astringency and bind excess harsh tannins common in red wines. It is often added to pressings to assist with clarification and to reduce the level of phenolic compounds associated with bitterness and astringency. Gelatine interacts mainly with larger polyphenolic compounds and is sometimes added in conjunction with tannin to provide better clarification. Of the proteinaceous fining agents, gelatine is the most aggressive and can easily result in over fining and colour removal. Gelatine is wine soluble and heat unstable therefore residual protein may remain in the wine if excessive amounts are used, potentially increasing the risk of the wine throwing a protein haze.

SO WHAT'S NEXT?

Polyvinylpolypyrrolidone, or PVPP, is used regularly in winemaking, but it is a plastic particulate and a unique fining agent in that it absorbs phenolic compounds and unwanted tannins. It also deactivates oxidative enzymes within wine. Because it is made of plastic, PVPP is insoluble in wine and can be completely removed after settling out with lees…but how does the fact that plastic is being used in the fining of your wines sit with you? Is this perhaps the next fining agent to be replaced or superceded?

Organic wine standards worldwide prohibit the use of PVPP, but when you try to find out what is so toxic about PVPP scientifically, it is hard to find. Organic standards have probably banned it because it is a synthetic ingredient, does not occur in nature and therefore is potentially toxic — but organic wine can be fined with animal proteins.

Perhaps another fining agent to be looked at, not so much under the banner of 'vegan friendly' or 'allergen free' but rather in regard to cost effectiveness and detrimental sensory loss at higher levels, is bentonite. One of the additives used most generally during winemaking, it can be used with other fining agents for the clarification of juice or wine, but is mainly used for the protein stabilisation of white wine. Its use, however, has certain disadvantages as it results in considerable product losses due to the percentage lost in lees.

Research in this field suggests that there might soon be alternatives that allow winemakers to choose the best option for their particular wines.

Some of the options are:

Carrageenan comes from red seaweed and is a renewable and natural product. Trials have shown that carrageenan is more selective than bentonite in removing wine proteins without also removing desirable wine sensory compounds. It is currently available but awaiting approval in export markets.

Grape seed powder — after roasting grape seeds at 180°C for 10 minutes, the seeds are then powdered. Because they contain high concentrations of polyphenols that readily bind to proteins, they are able to bind to haze-forming proteins in grape juice. The juice is then racked and fermented, producing clear, bright and protein-stable wine. This is now readily available and inexpensive.

In conclusion, whether we agree with veganism or not, it looks like it's here to stay. Thankfully, the products being developed in this space are as good, if not better, than the ones they have replaced.

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Float or sink?
Comparing the impacts of flotation and cold settling on the non-volatile composition, taste and mouthfeel of white wines

By Richard Gawel[1], Alex Schulkin[1], Damian Espinase Nandorfy[1], Paul Milton[2], Keren Bindon[1] and Paul A. Smith[1,3]

Flotation is a high-through-put continuous process for white juice clarification that is more efficient than traditional cold settling/racking. While the efficacy of flotation is well understood, its impact on white wine composition and sensory properties has been largely unexplored. This article presents results from a study comparing the effects of cold setting and flotation on the characteristics of Chardonnay and Frontignac wines.

IN BRIEF

■ Chardonnay and Frontignac juices were clarified by cold settling and by flotation using nitrogen gas prior to winemaking under commercial conditions, with wines produced from unclarified juice as controls.

■ The phenolic and polysaccharide profiles of wines produced using flotation were similar to those clarified by cold settling/racking, which was reflected in their similar mouthfeel and taste properties.

■ The wines produced by flotation were slightly more viscous than the wines made from either the settled or unclarified juice. The differences in perceived viscosity were best correlated with pH and total phenolic content.

INTRODUCTION

When white grapes are crushed, the resultant juice contains pulp and skin cell wall fragments called 'grape solids' (solids). Most solids are removed from juice prior to fermentation as their presence can lead to lower fruit expression either from enzymatic oxidation, decreased yeast esterase activity, or from the production of higher alcohols (Riberéau-Gayon *et al*. 1975). In commercial practice solids removal is often achieved by cold settling where the must is chilled, the solids settle to the bottom of the tank, and the clarified juice is racked into a second tank for fermentation. This process is effective but costly due to its high energy requirements and inefficient due to the necessity of using more than a single tank.

In the late 1990s winemakers began using flotation to clarify white juices, finding it more efficient and cost effective than cold settling due to its high flow and continuous nature (Falkenberg 1997). Flotation involves super-saturating white juices containing solids with either nitrogen or air, which upon depressurisation increases the buoyancy of the solid particles as they stick to the gas microbubbles and rise to the surface where they are removed by skimming. In practice, solids are floated off faster when pectolytic enzymes and a flocculating agent such as bentonite are added. The enzymes reduce juice viscosity and the flocculating agent increases microbubble formation and adherence to the solids (Marchall *et al*. 2003).

The economic efficiency of flotation has been compared with cold settling (Falkenberg 1997), as has its efficacy when using different flocculating agents, floating gases, temperatures and pressures (Davin and Sahraoui 1993). But how does juice clarification by flotation affect the composition and the resultant taste and texture of white wine when compared with wines made from cold settled and full solids juices?

METHODS

Juice preparation and winemaking

Chardonnay and Frontignac grapes from the Murray Valley region were processed into juice by different commercial wineries using similar protocols. Pectolytic enzymes were added at crush and the juice drained off skins into a pre-flotation storage tank. Two 20-litre juice samples of each treatment were collected for fermentation. These treatments (summarised in Table 1, see page 18) were:

- high solids (HS) taken from an upper racking valve of the storage tank to preclude gross solids
- low solids by settling (LS-SE) where HS juice was settled at 0ºC before being racked off fine solids
- low solids by flotation (LS-FL) produced by dosing in-line with bentonite before floating off solids using nitrogen gas at a discharge rate of 30kL/h.

The juice samples were chilled and adjusted to pH3.4 by tartaric acid addition and to a free SO_2 of 10-25mg/L. They were inoculated at the same time using *S. cerevisiae* strain EC1118 at 15-16°C. The resultant wines were racked and 60mg/L of SO_2 added; they were then cold stabilised at 0˚C using 4g/L KHT, pad and membrane filtered, adjusted to 35mg/L free SO_2 and bottled in 375mL units under screw cap.

Wine and juice analysis

The solids content of the high solids juices was measured as % wet weight, while the solids content of the floated and settled juices were determined by nephelometry (Table 2, page 18). Ethanol, organic acids ▸

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and glycerol were determined by HPLC, and other compounds given in Table 3 were determined by NIR spectroscopy. Total phenolic concentrations were determined using the Folin-Ciocalteu method. A targeted HPLC analysis of phenolic compounds representative of the major phenolic classes found in white wines was conducted by reverse phase C18 HPLC. Total wine polysaccharides were quantified by the phenol-sulfuric method, and the polysaccharide molecular weight distribution was determined by size exclusion chromatography.

Sensory methods

Nine assessors experienced in descriptive analysis rated the relevant taste and mouthfeel attributes (viscosity, astringency, hotness and bitterness) using an unstructured line scale. Samples of 30mL of wine were presented in an order and timing determined to minimise taste carry-over effects using ISO standard wine glasses at 22-24°C in isolated booths under daytime lighting.

RESULTS AND DISCUSSION

The solids content of the low-solids treatments produced by settling and flotation were similar (Table 2) and the wine compositional parameters were within acceptable ranges (Table 3).

Total phenolics in juice and wine

The floated Frontignac juice had significantly lower total phenolic concentration than the settled juice (Figure 1A). A similar but non-significant trend was observed in the Chardonnay juices. The lower total phenolics in floated juices compared with settled juices is consistent with previous studies (Ferrarini *et al*. 1995, Sindou *et al*. 2008) and may be explained by the shorter contact time between grape lees particles and juice experienced during flotation compared with settling (Table 1). The total phenolic concentrations of the high-solids juices were not significantly different from the cold-settled juice for both varieties, which is expected as the grape solids were in contact with the juice for the same duration. However, these explanations are speculative as the phenolic content of white grape solids and their extractability into juice pre-fermentation has yet to be determined. Another possible explanation is that some phenolics may have been removed from the floated juices by the bentonite added to improve the efficacy of flotation. Lastly, it should be noted that the differences in total phenolic concentration between treatments were relatively small compared with the average concentrations, suggesting that the majority of total phenolics were extracted into the juices prior to clarification (i.e. during crushing, draining and the settling and removal of coarse solids).

The effect of juice clarification on total phenolic concentrations in the bottled wines varied between the varieties. The total phenolic concentrations of the high-solids Frontignac wines were lower than those clarified by settling and flotation (Figure 1B), but the low-solids settled Chardonnay wines were higher in total phenolics than the high-solids and floated wines. Other researchers have also not observed a relationship between juice solids content and total wine phenolic concentration (Singleton *et al*. 1975, Sindou *et al*. 2008). However, here, the significant decreases in total phenolics seen after fermentation on high solids suggests that the solids may be acting as a phenolic 'fining agent', possibly related to non-covalent interactions with polysaccharides, which were in higher concentrations in these wines (Figure 3, see page 20).

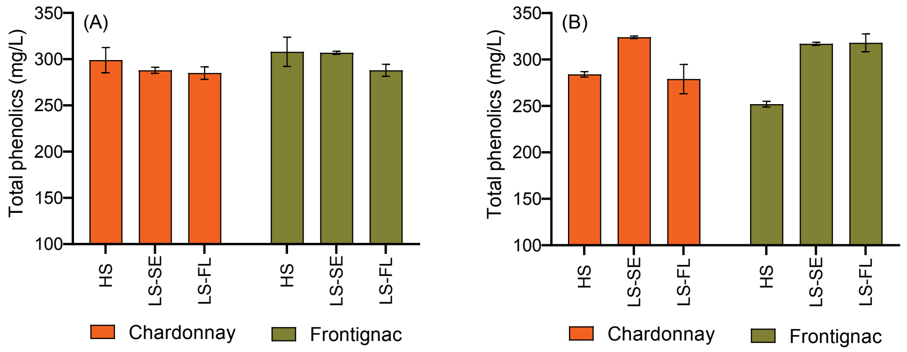

Figure 1. Total phenolics (A) juice and (B) wine expressed in gallic acid equivalents. HS – high solids, LS-SE – low solids via settling, LS-FL – low solids via flotation. Error bars represent two standard errors.

Table 1. Summary of winemaking procedures and contact of grape solids with juice and fermenting wine.

Treatment	High solids	Low solids-settled	Low solids -floated
Enzyme at crusher	Yes	Yes	Yes
Contact with gross lees	Yes	Yes	Yes
Bentonite addition to juice	No	No	Yes
N2 addition to juice	No	No	Yes
Contact time with grape solids (from racking off gross lees to yeast inoculation)	3.5 days	3.5 days	<0.1 hrs
Fermentation on high grape solids	Yes	No	No

Table 2. Solids content of winemaking treatments (n=2)

	High solids (% wt)	Low solids-settled (NTU)	Low solids-flotation (NTU)
Chardonnay	3.75%	100	97
Frontignac	2.75%	95	90

Wine phenolic profile

Wines made from settled and floated low-solids juices showed similar phenolic profiles, different from those produced from high-solids juices (Figure 2). Specifically, the wines made from low-solids juices had significantly higher concentrations of caftaric acid and generally lower concentrations of its derivative grape reaction product (GRP) than the high-solids wines. The ratio of caftaric acid to GRP can be influenced by SO_2, which may explain the differences between the two varieties as the grapes were processed in different wineries with different SO_2 regimes.

Table 3. Basic wine analysis (mean, n=2).

Treatment	Ethanol % (v/v)	Glucose + fructose g/L	pH	Titratable acidity g/L	Free SO2 mg/L	Total SO2 mg/L	Malic acid g/L	Volatile acidity g/L Acetic	Succinic acid g/L	Lactic acid g/L	Glycerol g/L
Chardonnay											
HS	13.9	0.95	3.45	5.6	35	155	2.9	0.25	3.3	0.5	7.2
LS-SE	14.0	1.00	3.48	5.9	32	202	3.3	0.37	3.3	0.5	7.6
LS-FL	13.8	0.90	3.45	6.2	32	163	2.8	0.32	3.3	0.5	7.1
Frontignac											
HS	11.0	0.55	3.51	4.4	30	160	0.7	<0.1	1.7	1.0	6.3
LS-SE	11.4	0.40	3.46	5.2	30	180	2.2	<0.1	1.8	0.5	6.0
LS-FL	11.1	0.55	3.56	4.3	32	167	0.5	<0.1	1.8	0.5	6.0

The combined concentrations of the monomeric flavan-3-ols, catechin and epicatechin were significantly higher in the settled wines than in the floated and high-solids wines (Figure 2). Ferrarini *et al.* (1995) also found that cold settling resulted in higher catechin concentrations in white Picpoul wine compared to flotation. The tyrosol concentrations of the settled and floated wines were similar, but the effect of high solids was variety dependent (Figure 2). Konitz *et al.* (2003) reported higher tyrosol concentrations in Riesling wines made from juice floated using air compared with those made from settled juices, a result which may be explained by a healthier yeast fermentation due to the must oxygenation.

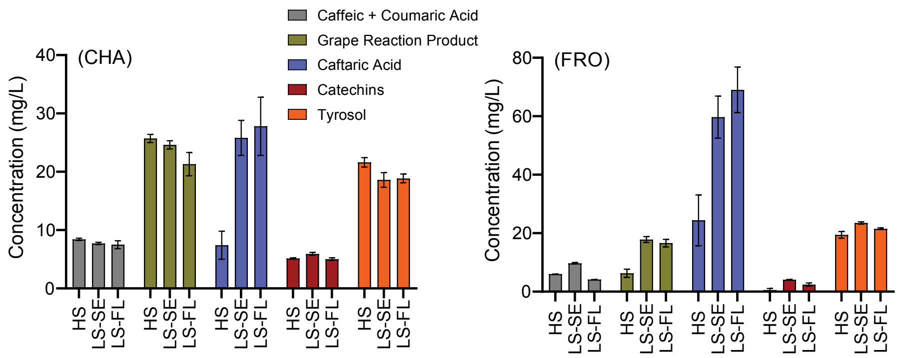

Figure 2. Mean concentration of phenolic compounds in wine. (CHA) Chardonnay, (FRO) Frontignac. Error bars represent two standard errors.

High-solids juices produced wines with a higher total polysaccharide concentration (Figure 3) and a higher proportion of high molecular weight polysaccharides (Figure 4, see page 20) compared with the wines produced from low solids juice using flotation. Previous work at the AWRI has shown that white wine polysaccharides greater than 93kDa consist mostly of mannoproteins derived from yeast during fermentation and yeast lees contact. This result is consistent with the knowledge that yeast-assimilable sterols adsorbed on grape solids help improve cell viability and maximum populations of yeast cells, particularly at the end of fermentation, which could promote the production and release of mannoproteins by yeast autolysis.

Wines made from low-solids juices clarified by cold settling and by flotation did not differ in total polysaccharide concentration (Figure 3) or their molecular weight profile (Figure 4), suggesting that the longer clarification time involved in cold settling compared with flotation did not result in significantly greater extraction of polysaccharides from the grape solids prior to fermentation.

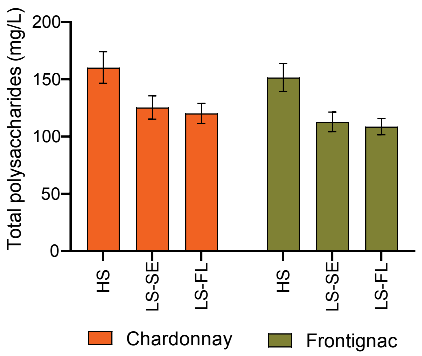

Figure 3. Concentration of total polysaccharides in wine as glucose equivalents. HS – high solids, LS-SE – low solids via settling, LS-FL – low solids via flotation. Error bars represent two standard errors.

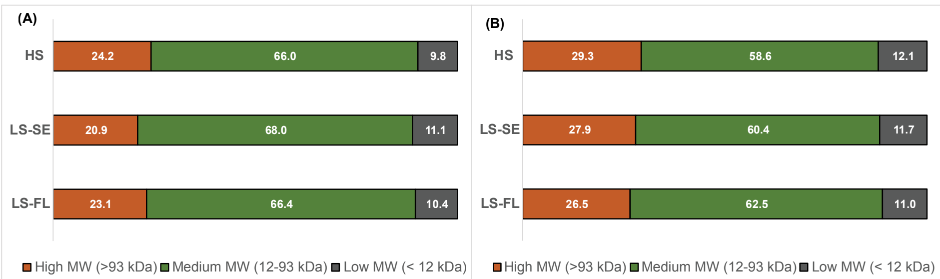

Figure 4. Polysaccharide molecular weight profile (A) Chardonnay, (B) Frontignac. Numbers inside bars represent percentages based on HPLC peak area. HS – high solids, LS-SE – low solids via settling, LS-FL – low solids via flotation

Sensory effects of clarification and relationship to composition

There was consistent evidence across both varieties that the wines made from floated juice were slightly more viscous and, in the case of Frontignac, the settled wines were significantly less bitter than the high-solids and floated wines (P<0.1). The hotness and astringency of the wines were not affected by the treatments applied.

Perceived viscosity correlated with total phenolics (Gawel *et al*. 2013) and specifically with caftaric acid concentration (P<0.05) (Gawel *et al*. 2014) but was most strongly correlated with pH (P<0.01); that is, greater perceived viscosity was positively associated with increasing pH (Runnebaum *et. al*. 2011). Higher total polysaccharide concentration was associated with lower perceived viscosity (P<0.1) (Figure 5), a result contradictory to that of some other studies which found higher concentrations of neutral polysaccharides in white and red wine increased their perceived viscosity (Vidal *et al*. 2004, Gawel *et al*. 2016).

The cold-settled Frontignac wines were less bitter than the high-solids and low-solids floated wines (P=0.05). The differences in bitterness cannot be attributed to total wine phenolics (Figure 1B) nor to any of the quantified phenolic compounds (Figure 3) including catechin and epicatechin, which elicit bitterness albeit at higher concentrations than found in these wines. This result, together with the lack of influence of ethanol (which also elicits bitterness) (Figure 5) suggests that the compounds responsible for the greater bitterness in the settled wines were not captured in this study.

	Total Polysaccharides	High MW PS	Med MW PS	Low MW PS	Glycerol	Glucose+Fructose	Ethanol
Viscosity	-0.595	-0.143	0.062	-0.045	0.032	0.159	0.036
Acidity	0.135	-0.102	0.359	0.358	0.061	-0.080	-0.008
Hotness	0.445	0.049	-0.275	0.040	-0.029	-0.102	0.012
Astringency	-0.149	-0.294	-0.062	-0.072	-0.023	-0.011	0.003
Bitterness	0.023	-0.229	0.054	0.061	0.008	0.019	0.009

	Total phenolics	GRP	Caftaric	Catechins	Caffeic+Coumaric	Tyrosol
Viscosity	0.691	0.249	0.574	0.317	-0.094	-0.105
Acidity	0.007	-0.037	-0.161	-0.081	-0.222	-0.192
Hotness	-0.422	-0.150	-0.319	-0.079	0.111	-0.052
Astringency	0.137	0.052	0.079	0.130	-0.183	-0.157
Bitterness	0.063	0.009	-0.026	0.054	-0.242	-0.200

	pH	Total acidity	Tartaric acid	Malic acid	Lactic acid	Succinic acid
Viscosity	0.735	-0.130	-0.252	0.049	-0.118	0.013
Acidity	-0.079	-0.007	0.111	-0.200	-0.227	-0.015
Hotness	-0.371	0.082	0.181	-0.034	0.127	-0.032
Astringency	0.361	-0.124	-0.075	-0.036	-0.015	0.007
Bitterness	0.279	-0.139	0.001	-0.132	0.016	-0.005

Figure 5. Heat map showing the correlation (r) between mouthfeel and taste characters and analytical parameters. Green indicates positive correlation and red negative correlation. Density of colour represents strength of correlation. Correlations in boxes were statistically significant (P<0.05).

SUMMARY

The composition and sensory qualities of Chardonnay and Frontignac wines made from juices clarified using flotation were compared with wines made using the less efficient method of cold settling. The non-volatile composition including total phenolics, total polysaccharides, phenolic profile and polysaccharide molecular weight profile of the wines produced by flotation were similar to those made using cold-settled juices, which was reflected in the wines having similar mouthfeel and taste properties. Both the Chardonnay and Frontignac wines produced by flotation by two different wineries were perceived to be slightly more viscous than the wines made from either the settled or unclarified juice. Perceived viscosity was best correlated with higher pH and higher total phenolic content.

ACKNOWLEDGEMENTS

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WVJ

Can SO_2 reduction in white wines be achieved by using CO_2 saturated grape musts?

By Pedro M. Izquierdo-Cañas[1,2*], Adela Mena-Morales[1], Esteban García-Romero[1], Lourdes Marchante[1], Victor Cejudo-Martín de Almagro[3], Sonia Guri-Baiget[3] and Jordi Mallén-Pomes[3]

With a view to exploring the possibility of partially or totally replacing sulfur dioxide during the winemaking proces, Spanish researchers investigated saturating musts with carbon dioxide and its effect on wine quality using Chardonnay.

IN BRIEF

- **Although one of the most used preservatives in the wine industry for its powerful antioxidant activity, antimicrobial effect and its influence on certain organoleptic characteristics, sulfur dioxide can also have negative sensorial effects on wine and can also adversely affect the health of consumers.**
- **Alternatives to SO_2 to replace or limit its use have been sought.**
- **Carbon dioxide is already used in winemaking such as in carbonic maceration and as a protective gas against oxidation in bottling; CO_2 is also produced during alcoholic fermentation.**
- **Spanish researchers evaluated the effects of saturating musts with CO_2 on wine quality and its evolution over time.**

USE OF SO_2 IN WINEMAKING

Sulfur dioxide is one of the preservatives most used in the wine industry due to its powerful antioxidant activity, antimicrobial effect, and its influence on certain organoleptic characteristics such as colour stability and aroma complexity. Microbiologically, SO_2 has an important antiseptic function proven to be specifically selective towards both acetic and lactic acid bacteria, and it also helps to determine the yeast population present. Furthermore, SO_2 exhibits an important antioxidant function that helps to reduce the effects of dissolved oxygen, and it inhibits the enzymes polyphenoloxidase, tyrosinase and peroxidase, which are endogenous in the grape and come from fungal infections. Particularly, the use of SO_2 is essential in the production of white wines to avoid oxidation reactions, which result in browning of white wines and chemical composition changes to the detriment of sensory quality.

However, SO_2 can also have negative sensorial effects, producing hydrogen sulfide and mercaptans odours due to yeast metabolism, or even adverse health effects such as the appearance of sensitivity and development of allergic reactions.

Therefore, one of the main challenges in the oenological field is finding alternatives to SO_2 for its replacement or limitation. In the past, several alternative methods and practices have been tested for emulating the preservative action of SO_2 without its negative side effects.

As a gas, carbon dioxide is widely used in fruit post-harvest for controlled atmosphere storage or the pre-shipping of strawberries and other berries sensitive to *Botrytis cinerea*. In the case of winegrapes, CO_2 is used for four main reasons: carbonic maceration, rapid cooling of grapes or must, in the carbonation of wines, and as a protective gas against oxidation in bottling. In addition to cooling, solid carbon dioxide releases CO_2 gas which can remove oxygen at room temperature.

During alcoholic fermentation, CO_2 is produced by the yeast metabolism. Saturating grape juice with CO_2 has interesting potential as an oenological technique, inhibiting undesirable species (*S. bacillaris* and *H. uvarum*) and stimulating non-*Saccharomyces* species of interest (*T. delbrueckii* and *P. kluyveri*). This stimulating effect was particularly marked when CO_2 saturation was associated with the presence of *S. cerevisiae* with long fermentation lag phase.

The aim of the current work is to study the possibility of partially or totally replacing SO_2 by using CO_2 saturation of musts in the pre-fermentative stage to evaluate the effect on quality or oenological characteristics of wine and its evolution over time. A total of five treatments have been tested with grape must of the Chardonnay variety, combining different CO_2 and SO_2 doses.

WINEMAKING

At the optimal moment of technological maturity, approximately 2000kg of Chardonnay grapes were harvested (21.72ºBrix; total titratable acidity 6.23g/L; pH3.60). Argon was used during the process of destemming, crushing and pressing to prevent oxidation. A total of 1000L of initial must was divided into two fractions. A first fraction of 200L which was not saturated with CO_2 and 50mg/L of SO_2 was added to obtain the 0% CO_2 - 50mg/L SO_2 wines, and another fraction of approximately 800L of must for the rest of treatments. In this second fraction, grape must was saturated with CO_2 up to 100%. The saturation of the must with CO_2 was made under atmospheric pressure, using Inyecvin equipment (Carburos Metálicos S.A., Spain) with a porous diffuser, reaching saturation by recirculating the must. The 100% saturation was achieved after 45 minutes of its application to the must, with a final concentration of 1700mg/L of CO_2.

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The second fraction of must (100% saturated with CO_2) was divided into four (200L each one). Wines obtained from the second fraction of must were 100% CO_2 - 50mg/L SO_2, 100% CO_2 - 25mg/L SO_2, 100% CO_2 - 0mg/L SO_2, adding to each of them the established doses of SO_2 at this time. Finally, the 50% CO_2 - 25mg/L SO_2 wines were obtained by mixing equal parts of the must from the first fraction (without CO_2), and the 100% CO_2 - 0mg/L SO_2 must. To carry out the racking, the five types of must were exposed at 15°C for 24 hours, and then each one was distributed homogeneously in three fractions of 30L that were fermented in tanks of 50L capacity.

Winemaking was carried out in triplicate for each treatment in vats of 50L in the experimental winery of IRIAF-IVICAM. Alcoholic fermentation was performed at 17ºC using the commercial yeast Uvaferm VN® (Lallemand Inc) at 20g/HL and the progress was tracked by monitoring the relative density. When a relative density value of 1.005 was reached, the wines were decanted and the alcoholic fermentation continued at 20ºC to completion, determined by the measurement of glucose + fructose concentration (<5g/L) using an enzymatic test kit. Subsequently, wines were racked and sulfited, with the exception of the treatment without SO_2. The SO_2 doses used at this stage were related to the initial SO_2 concentration added to the grape must. Wines obtained from the 0% CO_2 - 50mg/L SO_2 and 100% CO_2 - 50mg/L SO_2 treatments were adjusted to 30mg/L of free SO_2 before bottling. Wines from musts treated with 100% CO_2 - 25mg/L SO_2 and 50% CO_2 - 25mg/L SO_2 were corrected to a final free SO_2 concentration of 15mg/L and 100% CO_2 - 0mg/L SO_2 wines to 0mg/L of free SO_2 concentration. Then, the wines were passed through 0.2µm filters and sulfited until a final free SO_2 concentration of 30mg/L in wines from musts with 50mg/L of SO_2 and 15mg/L in wines from musts with 25mg/L of SO_2 was achieved. Finally, wines were bottled and stored at 16-18°C.

CHEMICAL ANALYSIS

The wines were analytically characterised following the official analytical methods. Volatile compounds were analysed by GC–MS. The sensory profile of the wines was evaluated by a panel of 15 expert tasters, using a sensory profiling: Napping®.

RESULTS

Oenological parameters

The oenological parameters of the wines three months after bottling are shown in Table 1. Alcoholic fermentation reached completion as indicated by the low values of residual sugars, glucose and fructose (≤0.24g/L). All wines showed optimal values of pH (3.33-3.54) and total acidity (5.14-5.33g/L). The values of volatile acidity (0.30-0.37g/L) are considered to conform to the standard quality parameter for volatile acidity in red table wines. The 0% CO_2 - 50mg/L SO_2 wines had the highest total acidity and the lowest pH. The lowest volatile acidity was obtained in 100% CO_2 - 0mg/L SO_2 wines, as opposed to wines from musts treated without CO_2 and 50mg/L of SO_2.

Total and free SO_2 concentrations concurred with the doses used initially in each of the types of musts treated, and the successive corrections of free SO_2 in the different stages of winemaking. A small concentration of SO_2 has been found in non-sulfited wines, something considered to be produced by yeasts. As for the secondary metabolites produced by the yeast during alcoholic fermentation, no significant differences were observed for glycerol content between the wines. Therefore, it can be concluded that the five types of wines had similar physicochemical parameters on a practical level and the saturation of musts with CO_2 did not decisively affect their oenological parameters.

All wines showed the same luminosity (L*), although statically significant differences in the CIELab a* and b* coordinates were found. The wines from musts saturated with CO_2 showed lower values of the a* coordinate (greener tones). The increase in the absorbance at 420nm and higher values of b* (more yellow tones) observed was inversely proportional to the SO_2 doses of the final wines.

Volatile compounds

From the gas chromatography analysis, the odour activity value (OAV) of each identified volatile compound was determined. In order to predict the overall impact of the CO_2 saturated musts on the aroma of the wines and the reduction of the SO_2 doses, different aromatic compounds were grouped into families according to the aromatic series: fruity, floral, green (fresh), sweet and fatty, among others. The total intensity of each aromatic family was

Table 1. Oenological parameters (mean value ± standard deviation, n=3) of white wines from grape musts treated with different CO_2 and SO_2 doses, three months after bottling.

	0% CO2 - 50 mg/L SO2	100% CO2 - 50 mg/L SO2	100% CO2 - 25 mg/L SO2	100% CO2 - 0 mg/L SO2	50% CO2 - 25 mg/L SO2
Alcoholic strength (% v/v)	13.05 ± 0.04	13.05 ± 0.02	13.00 ± 0.06	13.13 ± 0.07	13.04 ± 0.14
Total acidity (g/L)	5.33 ± 0.05 c	5.21 ± 0.06 ab	5.14 ± 0.03 a	5.14 ± 0.05 a	5.26 ± 0.04 bc
pH	3.33 ± 0.02 a	3.45 ± 0.01 b	3.48 ± 0.01 b	3.44 ± 0.01 b	3.54 ± 0.07 c
Total SO2 (mg/L)	129 ± 2 c	121 ± 6 c	65 ± 6 b	10 ± 2 a	63 ± 2 b
Free SO2 (mg/L)	31 ± 1 c	29 ± 3 c	14 ± 5 b	1 ± 1 a	12 ± 2 b
Glucose + Fructose (g/L)	0.24 ± 0.01 d	0.20 ± 0.01 b	0.19 ± 0.00 b	0.06 ± 0.01 a	0.22 ± 0.02 c
Volatile acidity (g/L)	0.37 ± 0.02 b	0.35 ± 0.01 b	0.34 ± 0.01 b	0.30 ± 0.02 a	0.34 ± 0.02 b
Malic acid (g/L)	2.84 ± 0.05	2.84 ± 0.08	2.86 ± 0.03	2.88 ± 0.05	2.92 ± 0.05
Lactic acid (g/L)	0.17 ± 0.01	0.16 ± 0.01	0.16 ± 0.00	0.16 ± 0.01	0.17 ± 0.01
Glycerol (g/L)	5.76 ± 0.05	5.93 ± 0.13	5.98 ± 0.05	5.97 ± 0.15	6.01 ± 0.08
L *	99.087 ± 0.133	98.844 ± 0.359	98.613 ± 0.232	98.802 ± 0.279	99.087 ± 0.179
a *	-1.232 ± 0.175 d	-1.404 ± 0.071 c	-1.530 ± 0.070 bc	-1.826 ± 0.032 a	-1.678 ± 0.038 ab
b *	5.663 ± 0.776 a	6.051 ± 0.176 a	7.250 ± 0.256 b	8.536 ± 0.160 c	7.408 ± 0.192 b
Absorbance at 420nm	0.081 ± 0.010 a	0.090 ± 0.005 a	0.107 ± 0.005 b	0.123 ± 0.005 c	0.104 ± 0.005 b

Mean values followed by different letters in a row are significantly different (p< 0.05 level), according to the Student-Newman-Keuls test.

calculated as the sum of the OAV of each of the compounds assigned to each one. The results are presented in Figure 1.

The saturation of the musts with CO_2 and the reduction of SO_2 doses produced statistically significant increases in three aromatic families: fruity, floral, and sweet. The combination of SO_2 and CO_2 increases the floral character, although in the case of the wines obtained from must saturated with 50% CO_2 and a dose of 25mg/L of SO_2, the increase in fruity character was not observed. Regarding floral character, there was an increase according to the degree of saturation of musts with CO_2. The wines from 100% saturated musts with CO_2 had higher levels of OAV for the compounds in the floral aromatic family than those saturated with 50% CO_2. This was not observed in the values obtained for the sweet family, in which an increase was identified with statistically significant differences with respect to the control wine, regardless of the degree of CO_2 saturation.

Sensory analysis

The score plot obtained by multiple factorial analysis (MFA) from the Napping® data is displayed in Figure 2a. Wines treated with 100% CO_2 - 25mg/L SO_2 and 0% CO_2 - 50mg/L SO_2 were grouped in a subset, 100% CO_2 - 50mg/L SO_2 and 50% CO_2 - 25mg/L SO_2 wines formed another subset and, finally, the wines from must saturated with 100% CO_2 and without SO_2. However, samples were not characterised from a sensory perspective using this technique, so another sensory analysis method was performed.

Figure 2b shows the sensory characteristics of wines identified using principal component analysis (PCA), obtained from the free comments of wine tasters. Combined, the results show that the 100% CO_2 - 0mg/L SO_2 wines were evaluated as the most aromatic ones with higher fruity, apple and herbaceous notes and great complexity in mouth at three months in bottle. On the other hand, the less aromatic and fruity wines were those obtained from the 0% CO_2 - 50mg/L treatment, although with more pineapple and floral notes being persistent in the mouth. The 100% CO_2 - 50mg/L wines were moderately aromatic, predominantly showing apple and herbaceous notes. The addition of 25mg/L of SO_2 and the saturation with 100% CO_2 (100% CO_2 - 25mg/L SO_2) produced more aromatic and fruity wines than the 0% CO_2 - 50mg/L

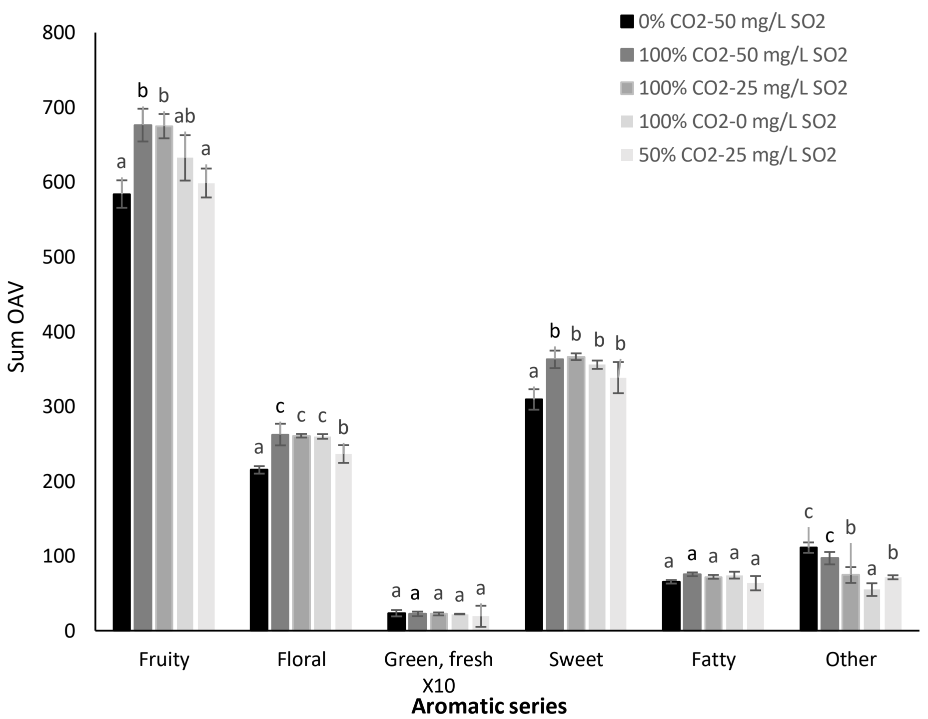

Figure 1. Aromatic series (Sum OAV) in the white wines from grape musts treated with different CO_2 and SO_2 doses: 0% CO_2 - 50mg/L SO_2, 100% CO_2 - 50mg/L SO_2, 100% CO_2 - 25mg/L SO_2, 100% CO_2 - 0mg/L SO_2 and 50% CO_2 - 25mg/L SO_2.

Table 2. Stability of white wines from grape musts treated with different CO_2 and SO_2 doses, twelve months after bottling.

	0% CO2 - 50 mg/L SO_2	100% CO2 - 50 mg/L SO_2	100% CO2 - 25 mg/L SO_2	100% CO2 - 0 mg/L SO_2	50% CO2 - 25 mg/L SO_2
Acetic acid (g/L)	0.37 ± 0.01 a	0.36 ± 0.01 a	0.34 ± 0.03 a	0.41 ± 0.04 b	0.35 ± 0.00 a
Malic acid (g/L)	2.78 ± 0.09 b	2.71 ± 0.05 b	2.80 ± 0.06 b	0.07 ± 0.12 a	2.81 ± 0.07 b
Lactic acid (g/L)	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a	1.67 ± 0.02 b	0.00 ± 0.00 a
L*	99.031 ± 0.194 b	98.967 ± 0.252 b	98.781 ± 0.100 b	96.678 ± 1.123 a	98.484 ± 0.199 b
a*	-0.844 ± 0.064 b	-0.928 ± 0.073 ab	-1.035 ± 0.058 ab	-1.172 ± 0.209 a	-0.879 ± 0.089 b
b*	6.157 ± 0.623 a	6.028 ± 0.207 a	7.190 ± 0.283 b	10.432 ± 0.610 c	7.327 ± 0.222 b
Absorbance at 420nm	0.084 ± 0.010 a	0.083 ± 0.005 a	0.100 ± 0.005 a	0.162 ± 0.020 b	0.106 ± 0.003 a

Mean ± standard deviation (n=3); mean values followed by different letters in a row are significantly different ($p < 0.05$ level), according to the Student-Newman-Keuls test.

SO_2, with more pear notes and tasting fresher and creamier. Finally, the 50% CO_2 - 25mg/L SO_2 wines were also aromatic and fruity and differentiated by a greater acidity in mouth.

Stability of wines at 12 months bottling

After 12 months of bottling, the colour of the different types of wine was similar, except for wines from 100% CO_2 - 0mg/L SO_2 treatment as evidenced by the values of L*, a*, b* and absorbance at 420nm (Table 2). The chromatic characteristic of wines from musts treated with CO_2 and without SO_2 showed lower lightness and a yellow colour with more greenish tones. For all wines, the values of acetic acid content were similar to the wines after bottling, which corroborates the absence of acetic acid bacteria during the conservation of wines in the bottle. Different results were obtained for malolactic fermentation (MLF). In 100% CO_2 - 0mg/L SO_2 wines, the transformation of L-malic acid to L-lactic acid occurred during the 12 months in bottle.

Sensory characterisation of the wines after 12 months in bottle is shown in Figure 3. The wines from 100% CO_2 - 0mg/L SO_2 treatment were evaluated as being among the most aromatic wines by tasters, like those analysed

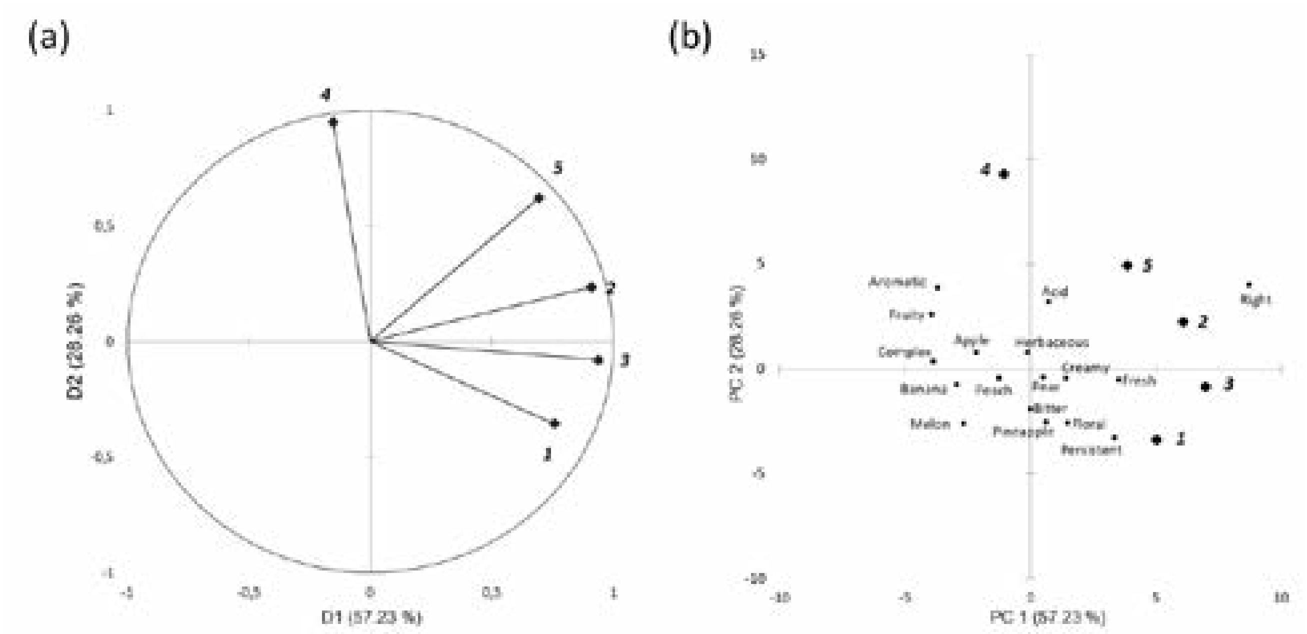

Figure 2. Sensory characterisation of white wines from grape musts treated with different CO_2 and SO_2 doses after three months of bottling by Napping® and Ultra Flash Profile: (a) MFA and (b) PCA. Treatments: (1) 0% CO_2 - 50mg/L SO_2, (2) 100% CO_2 - 50mg/L SO_2, (3) 100% CO_2 - 25mg/L SO_2, (4) 100% CO_2 - 0mg/L SO_2 and (5) 50% CO_2 - 25mg/L SO_2.

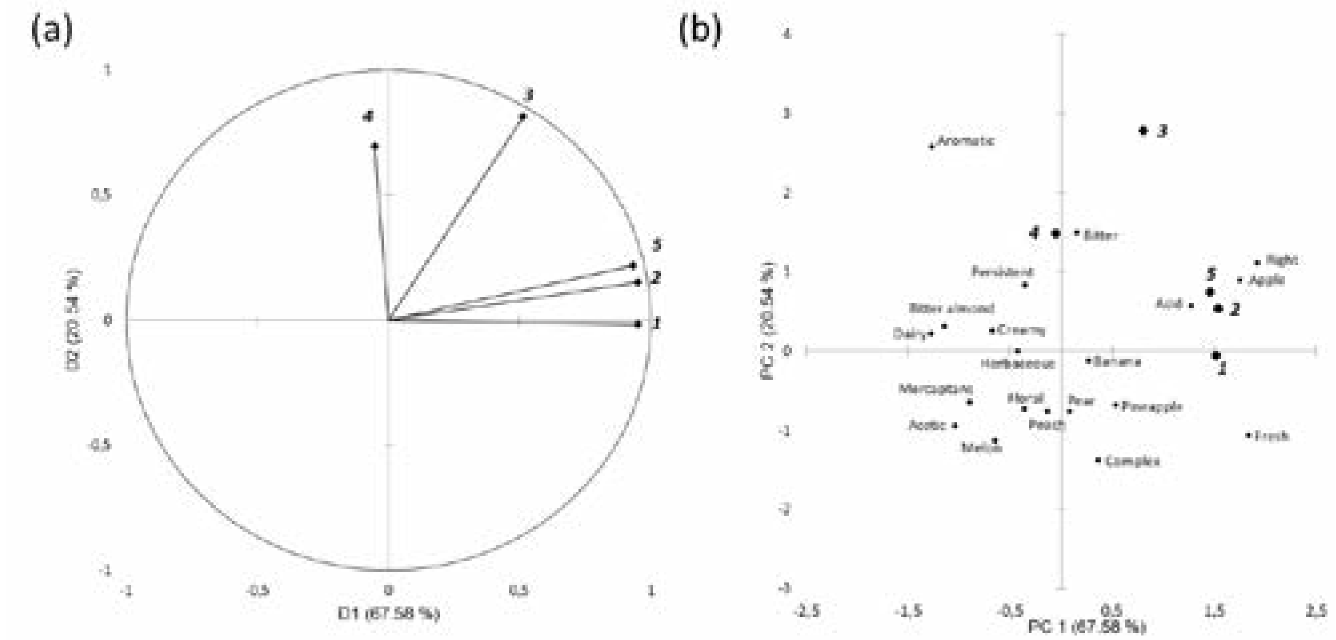

Figure 3. Sensory characterisation of white wines from grape musts treated with different CO_2 and SO_2 doses after 12 months of bottling by Napping® and Ultra Flash Profile: (a) MFA and (b) PCA. Treatments: (1) 0% CO_2 - 50mg/L SO_2, (2) 100% CO_2 - 50mg/L SO_2, (3) 100% CO_2 - 25mg/L SO_2, (4) 100% CO_2 - 0mg/L SO_2 and (5) 50% CO_2 - 25mg/L SO_2

three months after bottling. It is important to highlight the sensory evolution of 100% CO_2 - 25mg/L SO_2 wines, obtaining a better evaluation by the tasters after a year in bottle. The acidity of wines from must saturated with 50% CO_2 and 25mg/L of SO_2 was maintained over time.

CONCLUSIONS

CO_2 saturation of grape musts was used as an alternative to the use of SO_2 in the production of white wines. No important variations in the main oenological parameters of the wines were observed when grape musts were saturated with CO_2 and the use of SO_2 was reduced. The application of CO_2 in grape musts provided more aromatic and fruity wines. The stability of the wines was not affected from the perspective of the development of acetic acid bacteria, although MLF occurs in wines without SO_2. Finally, it could be concluded that the saturation of white musts with CO_2 may be a suitable technique to reduce the use of SO_2 during winemaking, providing stable wines over time with a distinctive aromatic and sensory profile.

ACKNOWLEDGEMENTS

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Sparging of white wines: *does it affect composition?*

By Wessel du Toit[1], James Walls[1] and Carien Coetzee[2]

South African researchers have assessed the effect of sparging on white wine composition and the factors affecting its efficacy, concluding that sparging appears to be a safe practice for lowering dissolved oxygen concentrations in wine if lost dissolved CO_2 can be replenished.

It is well known in the winemaking fraternity that excessive oxygen levels during wine production can lead to the unwanted oxidation of wine. One of the methods frequently employed by winemakers to lower dissolved oxygen levels in wine is to sparge the headspace of a wine bottle with an inert gas. Sparging has been used for a long period of time, but some wine producers still have reservations that it might 'strip' wine of certain desirable aroma compounds. However, surprisingly little research has been carried out on this commonly-performed winemaking practice. The factors affecting the efficacy of sparging is also not well known. The main aims of this study were thus to investigate the effect of sparging on the composition of white wines and to investigate the factors affecting its efficacy under winemaking conditions.

These experiments were conducted using experimental-scale 60L tanks, based in the experimental cellar of the Department of Viticulture/South African Grape and Wine Research Institute at Stellenbosch University. As can be seen from Figure 1, the tanks were set up to allow for controlled gas additions to wine, measuring oxygen levels in the wine, mixing of the wine with a stirrer and temperature control during sparging. The system thus allowed for real time monitoring of dissolved oxygen levels in the wine. For these experiments, the dissolved oxygen levels were raised to 3mg/L by sparging pure oxygen into the wine and then sparged with either N_2 gas or a mixture of N_2/CO_2 gas until a dissolved oxygen reading of lower than 0.3mg/L was observed. During the sparging process the stirrers in the tanks were also used to homogenise the wine.

FACTORS AFFECTING THE EFFICACY OF SPARGING

During sparging small inert gas bubbles are normally bubbled from the bottom of a tank containing a liquid such as wine or inline during the transfer of such a liquid. A process called mass transfer then takes place, which basically refers to the movement of dissolved oxygen from the liquid into the nitrogen bubble which then travels to the top of the liquid. Through this process the dissolved oxygen levels in the liquid can be lowered.

IN **BRIEF**

- **Sparging wine with an inert gas is frequently carried out to lower dissolved oxygen levels in wine to prevent oxidation.**
- **Some wine producers have reservations that sparging might 'strip' wine of certain aroma compounds, yet little research has been carried out to confirm this.**
- **South African researchers investigated the effect of sparging on the composition of white wines and the factors affecting its efficacy under winemaking conditions.**
- **Sparging with nitrogen did not appear to significantly influence the chemical composition of the wine, except concentrations of dissolved CO_2.**

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The efficacy of mass transfer in a liquid is dependent on a number of factors, such as the number of gas bubbles in the wine, the size of the gas bubbles, how quickly the gas bubbles travel to the top of the liquid and the resistance of the oxygen to cross the interface between the liquid and the gas bubble.

We first investigated the effects of different gas flow rates and bubble size on sparging efficacy in a young 2018 Chenin Blanc white wine. It was decided to use a nitrogen gas flow rate of 120mL and 280mL N_2 gas/L of wine per minute. These flow rates were in line with those tested by Wilson in 1985, which is one of the few publications on sparging in wine. In this first trial we used a 15-micron diffusion stone, made from stainless steel. We found little difference in the rate of oxygen removal between the two different flow rates, but more N_2 gas was required to lower the oxygen to less than than 0.3mg/L at the lower flow rate (Table 1, see page 29). Lower flow rates than 120mL N_2 gas/L of wine per minute were unfortunately not tested in this experiment. However, we found in other studies (Sutton *et al*. 2022) that higher gas flow rates can have a positive influence on oxygen removal under a certain maximum flow rate. The reason for not finding any difference between mass transfer or the efficacy of sparging over a certain maximum flow rate in this first trial is that N_2 gas bubbles tend to coagulate at too high gas flow rates. This leads to fewer, larger bubbles that travel faster to the top of the liquid. This leads to a lower bubble-to-liquid ratio as well as less contact time between the gas bubble

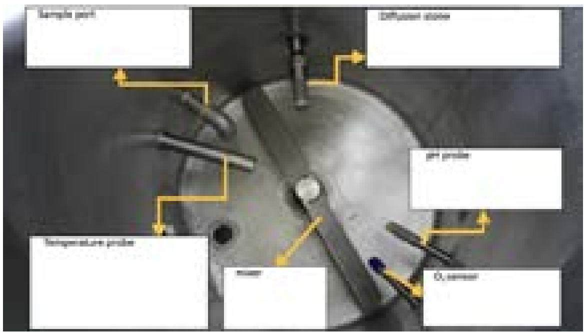

Figure 1a (top) and 1b (bottom). Tanks used in the sparging experiments. Source: Walls *et al*. 2022

and the wine, which negatively affects the movement of dissolved oxygen into the N_2 gas bubble, leading to a lower rate of oxygen removal from the wine.

This was further shown when we tested the effect of a 15-micron sparging stone vs the absence of a sparging stone. As expected, sparging with no stone drastically reduced oxygen mass transfer and hence the efficacy of the sparging process. A much larger amount of N_2 gas was, hence, also required to lower the dissolved oxygen levels in the wine (Table 1).

We next investigated the effect of sparging the Chenin Blanc wine at the two different flow rates, but at two different temperatures (10°C vs 18°C) at the two above-mentioned sparging flow rates. It was found that the sparging efficacy was significantly better at the higher temperature. The reason for this is that the viscosity of wine decreases at a higher temperature, which allows the oxygen to travel easier from the wine into the nitrogen bubble, hence leading to an increase in sparging efficacy.

In terms of the chemical effects of these sparging operations, almost no significant effects were observed in the wines. No significant differences were observed in the analyses of varietal thiols (3-mercaptohexanol [3MH]) and its acetylated derivative 3-mercaptohexyl acetate (*3MHA*), glutathione, SO_2 or colour in the before and after sparging experiments. 3MH and 3MHA are both important compounds in the guava and passionfruit descriptors of both Sauvignon Blanc and Chenin Blanc wines. However, the levels of dissolved CO_2 were influenced by the sparging procedures. This is due to dissolved CO_2 also moving into the N_2 bubbles and thus being removed from the wine. Interesting enough, the higher flow rate did not affect the rate of oxygen removal but led to larger concentrations of CO_2 being removed from the wine, which can be seen in Figure 2.

We next investigated the use of a mixture of N_2 and CO_2 gas as a sparging agent. The gas used was a mixture of 70% N_2 and 30% CO_2. A flowrate of 120g gas/L of wine per minute was used at both 10°C and 18°C in the Chenin Blanc wine. As with pure N_2 gas, the efficacy of oxygen removal was again better at the higher temperature when the mixed gas was used. However, the mixed gas was less effective in removing oxygen from the wine compared to pure N_2. This might be

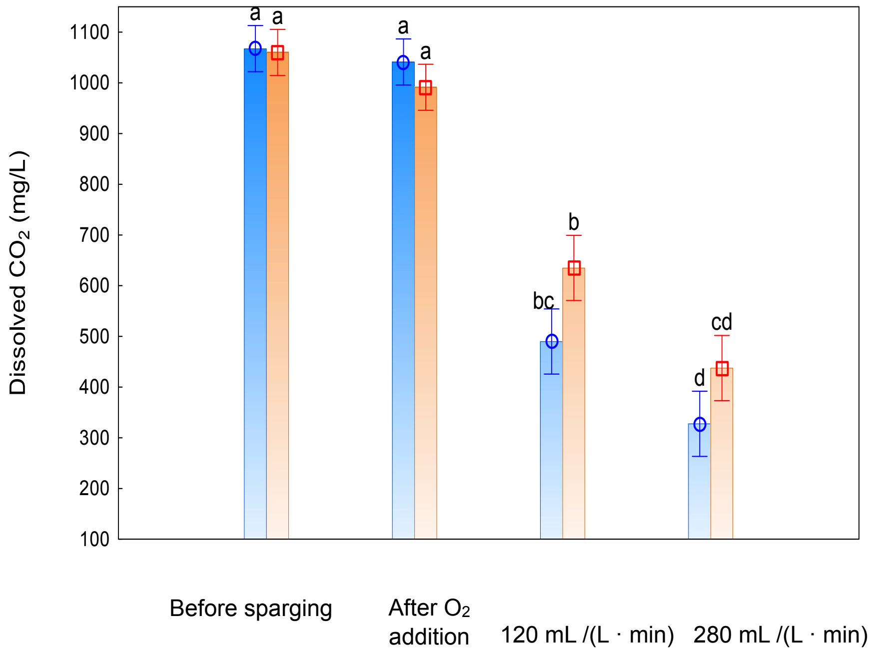

Figure 2. Levels of CO_2 (mg/L) in the Chenin Blanc wine sparged at 10°C (blue) or 18°C (orange) at different gas flow rates. Different letters indicate significant differences. Source: Walls *et al*. 2022.

because CO_2 can migrate from the bubble into the wine, resulting in the bubbles becoming smaller as they migrate to the top of the wine. There will thus be less surface area for oxygen to migrate into the gas bubble, leading to a lower mass transfer of oxygen into the gas bubbles. This result has also been found by other authors such as Wilson (1985) and Cant (1960). Interestingly, we also found that the CO_2 levels did not decrease significantly before and after sparging in the 18°C treatment. However, in the 10°C treatment it increased from around 1050mg/L to around 1200mg/L. At lower temperatures the solubility of CO_2 increases in wine, which led to this increase in CO_2 levels. For other compounds tested (varietal thiols, SO_2, glutathione and colour), the sparging again had no effect on their concentrations before and after sparging.

We then investigated the effects of repetitive sparging and over sparging. For the former trial we again used Chenin Blanc which had oxygen added to it to around 3mg/L, sparged with N_2 gas to dissolved oxygen levels below 0.3mg/L. This process was repeated four times. Again, no differences could be seen in the chemical compounds analysed, except for the CO_2 level which dropped to 0mg/L after the second sparging cycle.

In the last experiment we investigated the effect of over sparging on a wine's chemical composition. For this we used a 2018 Sauvignon Blanc wine. We found in other work that after around eight minutes, most of the dissolved oxygen has been removed. We thus decided to expose part of this wine to a sparging time of eight minutes, as well as an extended sparging time of 68 minutes. We wanted to assess if this 'over sparging' would have any chemical effects on the wine. We analysed a wider range of volatile compounds, such as varietal thiols, esters, higher alcohol, fatty acids and ketones as well as glutathione, SO_2 and colour. As can be seen in Table 1, the total amount of N_2 gas used per litre of wine was around 8.16mL N_2 gas/L of wine per minute, which was significantly more than those volumes used in some of the other experiments. Again, no significantly different values were obtained for all the compounds tested, except for the CO_2 levels which again dropped to around 0mg/L after the long sparging period.

RECOMMENDATIONS TO WINEMAKERS WHEN CONSIDERING SPARGING

Sparging wine with N_2 gas seems to be a safe method for lowering oxygen levels in wine, except for the lowering of CO_2 levels; we found that none of the volatile compounds tested were lowered by sparging. This was even the case when a very high volume of N_2 gas was introduced during the sparging process. Lowered CO_2 levels after sparging can be increased by sparging CO_2 gas into the wine after sparging with N_2 gas, or winemakers can consider using a mixture of N_2/CO_2.

Table 1. Volume of nitrogen or mixed gas required in each experiment. Source: Walls et al., 2022.

Experiment	Flow rate [mL N2 /(L wine · min)]	Temperature (°C)	Total N2 gas or mixed gas (L)/L wine
Temperature and flowrate	120	10	1.44†
	120	18	0.87
	280	10	3.41
	280	18	2.24
Mixed gas	120	10	1.51
	120	18	1.26
Diffusion stone	120 (with stone)	18	0.81
	120 (no stone)‡	18	6.89*
Repeated sparging	120	18	3.36
Extended sparging	120	18	8.16

†.‡Total volume of N2 sparged without a diffusion stone was extrapolated from O2 removal rate.

We previously discovered that wineries do not always monitor the flow rate of the gas being used for sparging. This is important as inert gas can be saved by monitoring and controlling the flow rate, which can be easily carried out through the use of a flow meter on a gas regulator. The temperature of the wine at the time of sparging is also important, with too low temperatures leading to the process being less effective.

However, the main factor that winemakers should keep in mind to achieve effective sparging is the use of a sparging stone. This is critical as smaller bubbles produced by such a stone will lead to much improved sparging efficiency, save time and lower costs in terms of gas expenditures.

Follow up work that we recently published (Sutton *et al*. 2022) showed that sparging protein stable wine also tends to increase the mass transfer of oxygen. We suspect that the proteins in protein-unstable wines might interfere with the ability of oxygen to move into an N_2 bubble.

The conditions under which sparging was carried out for our experiments were probably more effective than what one would encounter in a normal industrial size wine tank, which should be kept in mind when applying these results in a winery. The geometry of a tank will also play a role in sparging efficacy while using a stirrer, as we did in our work, will also increase sparging efficacy. This study nonetheless increases our understanding of sparging and its effects on wine.

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WVJ

Growing shoots of sustainability

By Mardi Longbottom, Ella Robinson and Mark Krstic, The Australian Wine Research Institute, PO Box 197, Glen Osmond, South Australia 5064

Mark Krstic

Since 2015, when the AWRI took on the management of what was then Entwine Australia, sustainability in the Australian grape and wine sector has come a long way. The National Sustainability Review in 2017 led to the merging of the McLaren Vale Grape Wine & Tourism Association Sustainable Australia Winegrowing program with Entwine to launch Sustainable Winegrowing Australia in July 2019 — a truly national program with ongoing leadership from Australian Grape & Wine, Wine Australia and the AWRI. Since then, the program has continued to blossom with significant membership growth, creation of a trust mark for use on wine bottles and increasing demand for certification. This article takes a look at recent developments and what's on the horizon.

STRENGTH THROUGH COOPERATION

One of the key strengths of Sustainable Winegrowing Australia comes from the three national organisations (Australian Grape & Wine, the AWRI and Wine Australia) working closely together, drawing on each other's skills and ensuring a truly national perspective. Australian Grape & Wine provides valuable strategic industry oversight through its Sustainability Advisory Committee as well as essential engagement via its regional networks. The AWRI contributes technical rigour and expertise to the program, ensuring it is backed by a strong scientific evidence base. Wine Australia provides its extensive marketing experience, expertise and networks to support the program, drive membership and communicate with markets both domestic and overseas. None of the three organisations can cover all of these bases, which means the program is so much stronger through working together.

PROGRAM STRUCTURE

Sustainable Winegrowing Australia members commit to annually reporting business metrics and completing a workbook of vineyard and/or winery practices. The data reported covers the environmental, social and economic components of sustainability and the program is relevant to vineyards, wineries and wine businesses. In October each year members can access individual, customisable benchmarking reports, showing their performance in the context of other members. This allows opportunities for improvement to be easily identified and then tracked. Members who choose to be certified undergo an independent third-party audit once every three years, in addition to maintaining Sustainable Winegrowing Australia membership.

MEMBERSHIP GROWTH

In the first year of Sustainable Winegrowing Australia (2019-20), there were approximately 480 members, representing 23% of Australia's vineyard area and 18% of winegrapes crushed. Now, almost three years on from the launch, membership has grown to 865 members, 87% of which are vineyard members, 12% winery members and 1% in the new category of wine business members. Approximately 20% of members have taken the additional steps to become certified. This significant membership growth is testament to the efforts of the team to clearly communicate the benefits of membership and support new members in their sustainability journey. The new wine business category was developed

Photo: Ovis Creative

Launched in 2020, Sustainable Winegrowing Australia's trust mark is available for use by certified members of the program on wine labels, vineyard signs and other marketing materials — it is currently used by 83 certified members on 91 signs, 64 wine labels and by 20 members in their branding and promotions.

and launched in response to feedback from businesses that did not fit the traditional vineyard or winery categories, but still wanted to contribute to our industry's growing sustainability movement.

TRUST MARK AND INCREASED DEMAND FOR CERTIFICATION

One key factor in the membership growth experienced has been the development of a trust mark for the program. Launched in July 2020, the trust mark is available for use by certified members of the program on wine labels, vineyard signs and other marketing materials. Uptake of the trust mark has been strong, with it currently being used by 83 certified members on 91 signs, 64 wine labels and by 20 members in their branding and promotions. The increased visibility of the trust mark is also helping to drive demand from members to seek certification, as evidenced by significant growth in demand for certification training workshops, which are a key step in the certification process.

GRASSROOTS ACTIVITIES

Local community engagement, particularly at the regional level, has been another very important aspect of the program's recent growth. Assistance has been provided to a number of regions to apply for grants to support uptake of the program. In regions where these applications have been successful, such as Yarra Valley, Rutherglen, Margaret River, Barossa, Adelaide Hills, Langhorne Creek and McLaren Vale, one-on-one assistance has been made available to producers to help them either join the program for the first time or take the next steps towards certification. The enthusiasm and commitment displayed by the regional organisations and their members to drive adoption of Sustainable Winegrowing Australia right across their region has been really inspiring. We look forward to continuing to work with regions on their sustainability priorities.

INTERNATIONAL INVOLVEMENT

Positioning Sustainable Winegrowing Australia within the international marketplace is a further key priority to ensure the program is recognised overseas and Australian producers are rewarded for their efforts. This involves a range of ongoing activities including:

- engagement with large international purchasing groups (e.g. Systembolaget, LCBO etc) to ensure they understand and value the program
- participation in international benchmarking processes to ensure the program continues to operate at best practice
- contribution to international working groups such as the Sustainable Wine Roundtable, which is currently investigating whether or not it is feasible to develop an international sustainability standard
- developing further understanding of the importance of sustainability as a market access issue through a planned review of the international marketplace to understand customer sustainability requirements and identify any gaps in the program.

IMPACT REPORT

Sustainable Winegrowing Australia recently released its first impact report (available from sustainablewinegrowing.com.au) which summarises the progress that Sustainable Winegrowing Australia members are making across six key areas. Within the report, metrics on member actions and achievements are put in context with member stories and testimonials. Some key highlights from this report include:

- 87% of vineyard members and 79% of winery members have taken action to plan, monitor and reduce water use
- 72% of vineyard members and 82% of winery members have taken action to reduce energy consumption
- 68% of vineyard members and 62% of winery members have taken action to protect and enhance biodiversity
- 72% of vineyard members and 89% of winery members have taken action to reduce waste to landfill and identify recycling and reuse options.

The impact report has been distributed to all members.

WHAT'S NEW?

Qantas has recently partnered with Sustainable Winegrowing Australia as part of its new Green Tier program. Wines from certified member wineries are now being promoted to Qantas Frequent Flyer members, with purchasers gaining credit for choosing these sustainable products. This is a great example of a partnership between two organisations that value sustainability, with benefits for both consumers and producers.

A number of other agricultural and horticultural industries are taking notice of the grape and wine industry's sustainability focus. The program team has been approached by representatives from several different sectors interested in learning more about Sustainable Winegrowing Australia and how it might be adaptable to their grower and producer communities. It is pleasing that the efforts made by grape and wine producers to improve the sustainability of their practices are inspiring others to take similar action.

WHAT'S COMING UP?

The AWRI has recently commenced a collaboration with researchers at the University of Adelaide on a pilot project on soil carbon, which aims to provide our industry with tailored information on measuring soil carbon, practices to increase carbon sequestration and advice on the costs and benefits of participating in government emissions reduction programs. This will address a current knowledge gap which is currently making Australian growers hesitant to invest in soil carbon enhancement practices while the return on investment is unclear. The project has potential to incorporate soil carbon decision tools into Sustainable Winegrowing Australia.

In addition, sustainability will be one of the key themes at the Australian Wine Industry Technical Conference in Adelaide in June 2022 with one of the plenary sessions focusing on a roadmap for a sustainable industry and a workshop on what sustainability means for small, medium and large producers. Sustainable Winegrowing Australia will also be part of the WineTech trade exhibition, in conjunction with Freshcare, the organisation that maintains the wine industry sustainability standards.

There is also momentum from within our industry to adopt more aggressive sustainability targets, in line with high-level strategic goals. Sustainable Winegrowing Australia will need to adapt and develop the metrics to support this, an example of continuous improvement in action both within and outside the program. The three lead organisations will be working together on this next phase of the program's development.

HOW TO GET INVOLVED

For grape and wine businesses interested in learning more about Sustainable Winegrowing Australia, the first point of call should be the program's website: www.sustainablewinegrowing.com.au. Detailed FAQs are available to answer the most common questions about the program and membership. There's also the option to sign up for a short series of emails with tips on program benefits and help to gather the information needed for membership. Assistance is also always available from the friendly members of the AWRI helpdesk team via helpdesk@awri.com.au

CELEBRATING ACHIEVEMENTS WHILE CONTINUING TO EVOLVE

Sustainable production is not a destination, it's an ongoing cycle of identification, planning, action and review. Sometimes we can get caught up in that cycle and forget to celebrate the achievements that have already been made. The Australian grape and wine community's sustainability achievements are worth celebrating and so is the growth and impact of Sustainable Winegrowing Australia over the past three years. Under the joint leadership of Australian Grape & Wine, Wine Australia and the AWRI, the program will continue to grow and evolve as our community and our markets increase their focus on sustainability.

ACKNOWLEDGEMENTS

The authors would like to thank Tony Battaglene and Anna Hooper (Australian Grape & Wine) and Martin Cole, Drea Hall, Alex Sas, Steven Weinert (Wine Australia) and Liz Pitcher (AWRI) for their hard work and dedication to the success of Sustainable Winegrowing Australia.

Launched in July 2019, Sustainable Winegrowing Australia is a relatively young program that draws on the strengths of its predecessor programs, including Entwine Australia and Sustainable Australia Winegrowing (SAW). It acknowledges the contributions of many individuals and organisations dedicated to promoting and progressing the sustainable production of Australian grapes and wine. More information about those who have contributed are included in the Sustainability Timeline and Contributions sections of www.sustainablewinegrowing.com.au.

The AWRI's communications are supported by Australia's grapegrowers and winemakers through their investment body, Wine Australia, with matching funding from the Australian Government. The AWRI is a member of the Wine Innovation Cluster in Adelaide.

Susceptibility of pruning wounds to grapevine trunk disease pathogens in the Adelaide Hills

By Mark Sosnowski[1,2] and Matthew Ayres[1]

Research funded by Wine Australia has revealed that the timing of winter pruning influences the susceptibility of wounds to infection by grapevine trunk disease pathogens in the Adelaide Hills region, highlighting the importance of localised research to investigate wound susceptibility that takes into account varying climates and the prevalence of trunk pathogen species in Australian wine regions.

INTRODUCTION

The grapevine trunk diseases Eutypa dieback (ED) and Botryosphaeria dieback (BD) — caused by the fungal pathogens *Eutypa lata* and *Diplodia seriata*, respectively — pose a serious threat to vine health and longevity. Fungal spores are released from fruiting bodies in dead, infected wood following rain and land on exposed pruning wounds where they infect and colonise the woody tissue, slowly destroying the vascular system, often eventually killing the vine.

Studies have been conducted worldwide into the susceptibility of grapevine pruning wounds to infection by grapevine trunk disease pathogens. Research conducted in Australia on apricots 50 years ago (Carter and Moller 1967, 1970) reported that wounds were susceptible to infection by *E. lata* for up to four weeks during early winter, with decreased susceptibility in late winter and early spring. Since then, grapevine pruning wounds have also been reported to be more susceptible to *E. lata*, and for a longer duration, in early winter than in spring in California (Moller and Kasimatis 1980, Petzoldt *et al.* 1981 and Munkvold & Marois 1995). In contrast, wounds were reported with higher susceptibility in late winter and early spring than in early winter in south-west France (Chapius *et al*. 1998), Michigan (Trese *et al*. 1982) and South Africa (van Niekerk *et al*. 2011). Serra *et al*. (2008) reported that in Italy, wounds were susceptible to infection by BD pathogens for up to 16 weeks with no difference between winter and spring pruning times. In California, Úrbez-Torres and Gubler (2010) reported wound susceptibility duration of 12 weeks with decreased susceptibility in late winter and early spring compared with early winter, while in South Africa, van Niekerk *et al*. (2011) reported susceptibility of 21 days or more with greatest susceptibility when pruned in late winter compared with early winter. More recently, comprehensive research trials were conducted in Australia to examine the susceptibility of grapevine pruning wounds to infection by *E. lata* in the warm-dry climate of McLaren Vale, South Australia, and the BD pathogens *D. seriata* and *Neofusicoccum luteum* in the hot-dry climate of Wagga Wagga, New South Wales, according to climatic classifications proposed by Scholefield and Morison (2010) based on Dry *et al*. (2004). Wounds were highly susceptible to infection immediately following pruning, and susceptibility decreased sharply over the following two weeks, and at varying rates, depending on the pathogen being evaluated, the year of the trial and the region (Ayres *et al*. 2016, Sosnowski *et al*. 2017).

These reports from different regions around the world indicate that there is variation in the duration of susceptibility of grapevine pruning wounds to infection by trunk disease pathogens at different times during the pruning season. Localised research is required to gain an understanding of the periods of greatest wound susceptibility in different climatic regions. This will allow growers to better target their wound protection strategies to times of greatest need. Therefore, research has extended pruning wound susceptibility evaluation to the warm-wet region of the Adelaide Hills, South Australia.

IN BRIEF

- Grapevine trunk disease is caused by fungi that are spread by airborne spores.
- These spores infect exposed pruning wounds where the fungus progressively kills spurs, cordons and trunks.
- Reports from different regions around the world show that there is variation in the duration of susceptibility of grapevine pruning wounds to infection by trunk disease pathogens at different times during the pruning season.
- Research carried out in the Adelaide Hills has shown that pruning wounds are susceptible to infection by spores in the first two weeks after pruning.

METHODS

A vineyard trial was established in 2017 on cv. Shiraz vines planted in 1997 near Hahndorf, in the Adelaide Hills. One-year-old canes were pruned to four buds in early June, mid July and late August in 2017 using secateurs (Figure 1, page 36). For each pruning time, wounds were inoculated at intervals between one and 42 days following pruning for *E. lata*, and at intervals of between one and 84 days for *D. seriata*. Wounds were inoculated with approximately 200 spores using a pipette (Figure 2, page 36). A non-inoculated control (NIC) was also included at each pruning time to monitor natural infection. Each treatment was allocated to a vine with 10 pruned canes. The trial was set up as a randomised block design with five replications, and was repeated in 2018.

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Figure 1. Shiraz canes pruned to four-bud spurs in Adelaide Hills.

Figure 2. Inoculating pruning wound with fungal spores using a pipette.

Canes were removed from vines in early May the following year, up to 11 months after trial establishment, and returned to the laboratory for assessment. Bark was removed from each cane using a sharp knife and the exposed wood was disinfested in bleach and rinsed in sterile water. Canes were cut into small pieces that spanned the interface between normal and stained wood tissue and placed onto agar plates. Samples were incubated for seven days and then assessed for the presence or absence of mycelial growth of each pathogen. Data were statistically analysed and standard error of the means were calculated.

RESULTS

Mean recovery from wounds inoculated with *E. lata* was significantly lower for the vines pruned in late August (24-36% when inoculated one day post-pruning) than for vines pruned in early June (75-100%) and mid July (46-89%, Figure 3). For the early June pruning time, mean recovery of *E. lata* was reduced significantly to 5-13% when inoculated 14 days post-pruning. In mid July, recovery reduced to 14-17% when inoculated seven days post-pruning and in late August, recovery reduced to 11-13% when inoculated 21 days post-pruning. For the early June and mid July pruning times, mean recovery rates for wounds inoculated 14 to 42 days post-pruning were similar to those for the NICs (0-15%), and for the late pruning time, recovery rates for wounds inoculated 21-42 days post-pruning were similar to those for NICs (6-10%).

Mean recovery from wounds inoculated with *D. seriata* was similar across all pruning times with recovery ranging between 55 and 87% when inoculated one day post-pruning (Figure 4, page 38). For all three pruning times, recovery was significantly reduced to 2-10% from vines inoculated 14 days post-pruning and for inoculation times from 28 to 84 days post pruning, recovery rates were similar to those of the NICs (0-7%).

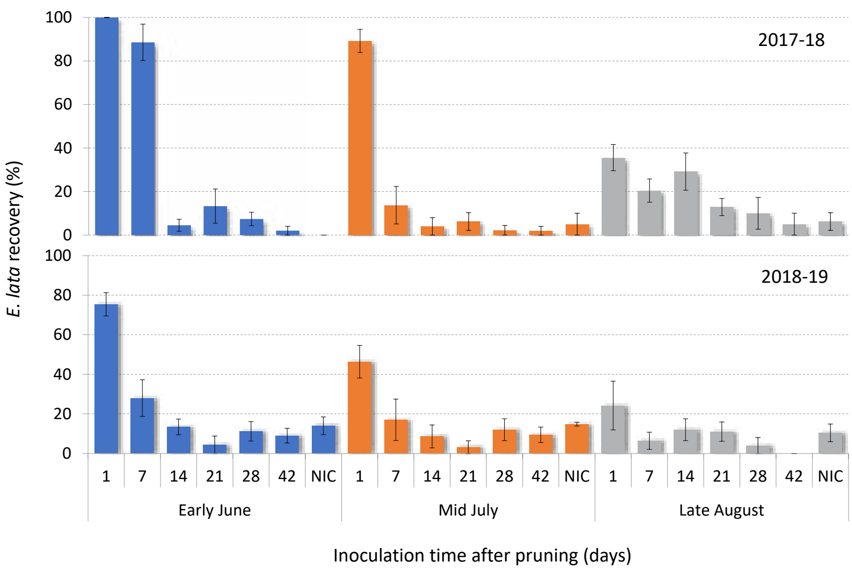

Figure 3. Incidence of recovery of *Eutypa lata* in the Adelaide Hills trial from canes pruned in early June, mid July and late August in 2017 and 2018. Wounds were inoculated with 200 spores at intervals between 1 and 42 days after pruning. NIC = non-inoculated control. Bars represent standard error of the mean.

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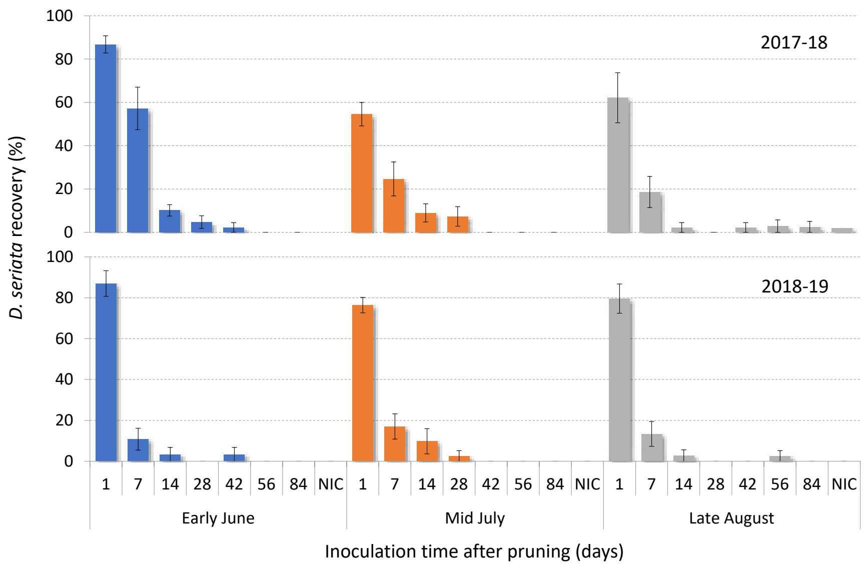

Figure 4. Incidence of recovery of *Diplodia seriata* from canes pruned pruned in early June, mid July and late August in 2017 and 2018. Wounds were inoculated with 200 spores at intervals between 1 and 84 days after pruning. NIC = non-inoculated control. Bars represent standard error of the mean.

DISCUSSION

Pruning wounds were highly susceptible to ED and BD pathogens immediately following pruning, after which the susceptibility usually decreased rapidly over the following 14 days. From 21 days post-pruning, susceptibility was generally negligible and often similar to the NICs. This indicates that wounds are most vulnerable to infection for the first 14 days following pruning, similar to that reported for *E. lata* on apricot by Carter and Moller (1970) and more recently reported for *E. lata* and *N. luteum* on grapevines in McLaren Vale and Wagga Wagga, respectively (Ayres *et al.* 2016). However, in Wagga Wagga, *D. seriata* was recovered from wounds for a longer duration following pruning than recorded in the Adelaide Hills. This may be partly due to the very high natural levels of *D. seriata* recorded in the Wagga Wagga trials (up to 35% recovery from NICs) compared with the very low levels recorded in the Adelaide Hills (only 2% on one occasion). Furthermore, the *D. seriata* inoculum dose used in the Adelaide Hills trial was 200 spores, compared with 1000 spores in the Wagga Wagga trial, possibly reflecting lower disease pressure in the Adelaide Hills trial, closer to that of natural infection levels.

Carter and Moller (1971) showed that on apricots as few as 10 *E. lata* spores would be expected to naturally infect a single pruning wound. So, although high spore doses may be necessary to ensure good recovery of the pathogen in an experimental situation, this may lead to an un-naturally high disease pressure, which may also influence the apparent rate of wound healing. Elena *et al*. (2015) reported 8-45% recovery from grapevine wounds inoculated with only 10 spores of either *E. lata* or *D. seriata*, which increased to 90-100% when inoculated with 500 or 1000 spores, respectively. Therefore, the longer duration of susceptibility to infection by BD pathogens reported by Serra *et al*. (2008) and Úrbez-Torres and Gubler (2010) could be due to the high spore doses used, ranging between 2500 and 5000 spores per wound. The use of only 200 spores per wound in the current study, although still higher than expected to occur naturally, may help provide a more realistic curve of wound susceptibility over time.

With regard to wound protection, fungicide timing trials indicated that ED and BD pathogens are controlled when wounds are treated with fungicide up to six days after infection, and will continue to provide control of both pathogens for one to two weeks (Ayres *et al*. 2017, 2022). Therefore, a single application of a registered fungicide could provide two to three weeks of wound protection, which covers the most susceptible period of two weeks post-pruning.

Pruning wounds were generally most susceptible to infection by *E. lata* when pruned in early June and least susceptible when pruned in late August, supporting reports from California (Moller and Kasimatis 1980, Petzoldt *et al*. 1981 and Munkvold and Marois 1995). However, susceptibility of wounds to *D. seriata* did not vary greatly between pruning times, similar to that reported in Italy by Serra *et al*. (2008). Contrasting trends were reported in France (Chapius *et al*. 1998), Michigan (Trese *et al.* 1982) and South Africa (van Niekerk *et al*. 2011), which may be due to environmental, climatic or cultivar differences.

These results indicate that, in the Adelaide Hills, there may be an advantage in delaying pruning to later in the dormant season to minimise the risk of infection by *E. lata*. In the case of *D. seriata*, there appears to be no real advantage in avoiding the early pruning time. However, over the course of the trials, only one incidence of natural infection of pruning wounds by *D. seriata* was recorded in the non-inoculated control wounds, and a spore trap located at the site detected very low levels of BD pathogen spores (unpublished data) which indicated very little presence of this pathogen in this region. These results contrast with previous research (Ayres *et al*. 2016, Sosnowski *et al*. 2017) that showed little advantage in choosing one pruning time over another in the McLaren Vale and Wagga Wagga regions. The variability observed between different climatic regions highlights the importance of localised research to investigate wound susceptibility. Future research should focus on other climatic regions in order to ascertain the periods of greatest wound susceptibility.

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The effect of sulfur on the efficacy of demethylation inhibitor fungicides on powdery mildew

By Ismail Ismail[1,2], Suzanne McKay[1,2] and Mark Sosnowski[1,2]

The study described below was conducted to evaluate the efficacy of three DMI fungicides to control powdery mildew on grapevines when mixed with sulfur. Funded by Wine Australia, the study showed that all DMI/ sulfur mixes significantly reduced powdery mildew disease whether or not the Erysiphe necator population contained a high frequency of the Y136F mutation associated with resistance to DMI fungicides.

INTRODUCTION

Powdery mildew, caused by *Erysiphe necator,* is one of the most economically important diseases of grapevines in Australia. The demethylation inhibitors (DMIs) (FRAC code 3) and sulfur (FRAC code M02) are important fungicides for the control of powdery mildew, and are used in conjunction to manage fungicide resistance in grapevines (Emmett *et al*. 2003).

There is growing concern about the possible antagonism between DMIs and sulfur when they are mixed in a spray tank. There are a few reports that state sulfur might negatively impact the efficacy of DMIs. Steva (1994) reported that the uptake of the DMI Bayfidan® into grapevine foliage was reduced from 70% to 10% when it was tank-mixed with sulfur, decreasing the control of powdery mildew. Alternating sulfur with DMI fungicides in vineyards with fungicide resistance resulted in better disease control than tank mixing DMIs and sulfur (Ypema *et al*. 1997). However, agrochemical companies state that sulfur is compatible with DMI fungicides. Therefore, the aim of this research was to investigate the effect of tank mixing DMIs with sulfur on powdery mildew control.

Figure 1. Mini greenhouse with side ventilation windows covered with spore proof fabric to prevent cross contamination.

METHODS

Cabernet Sauvignon vines were grown from cuttings in pots for six weeks in Naturallife® mini greenhouses maintained at 25-27°C (Figure 1). Mini greenhouses have been routinely used to maintain *E. necator* isolates and the ventilation windows are covered with spore-proof fabric to prevent cross-contamination.

Plants were removed from the mini greenhouses and placed in a humidity tent. Ten to 15 leaves on each plant were tagged for inoculation. Four wild-type isolates (lacking the Y136F mutation associated with DMI resistance) and four isolates with high frequency of the Y136F mutant, previously confirmed by Next Generation Sequencing (Australian Wine Research Institute), were used for the experiments. Inoculum was prepared by using four to five heavily infected leaves harvested from plants infected with a

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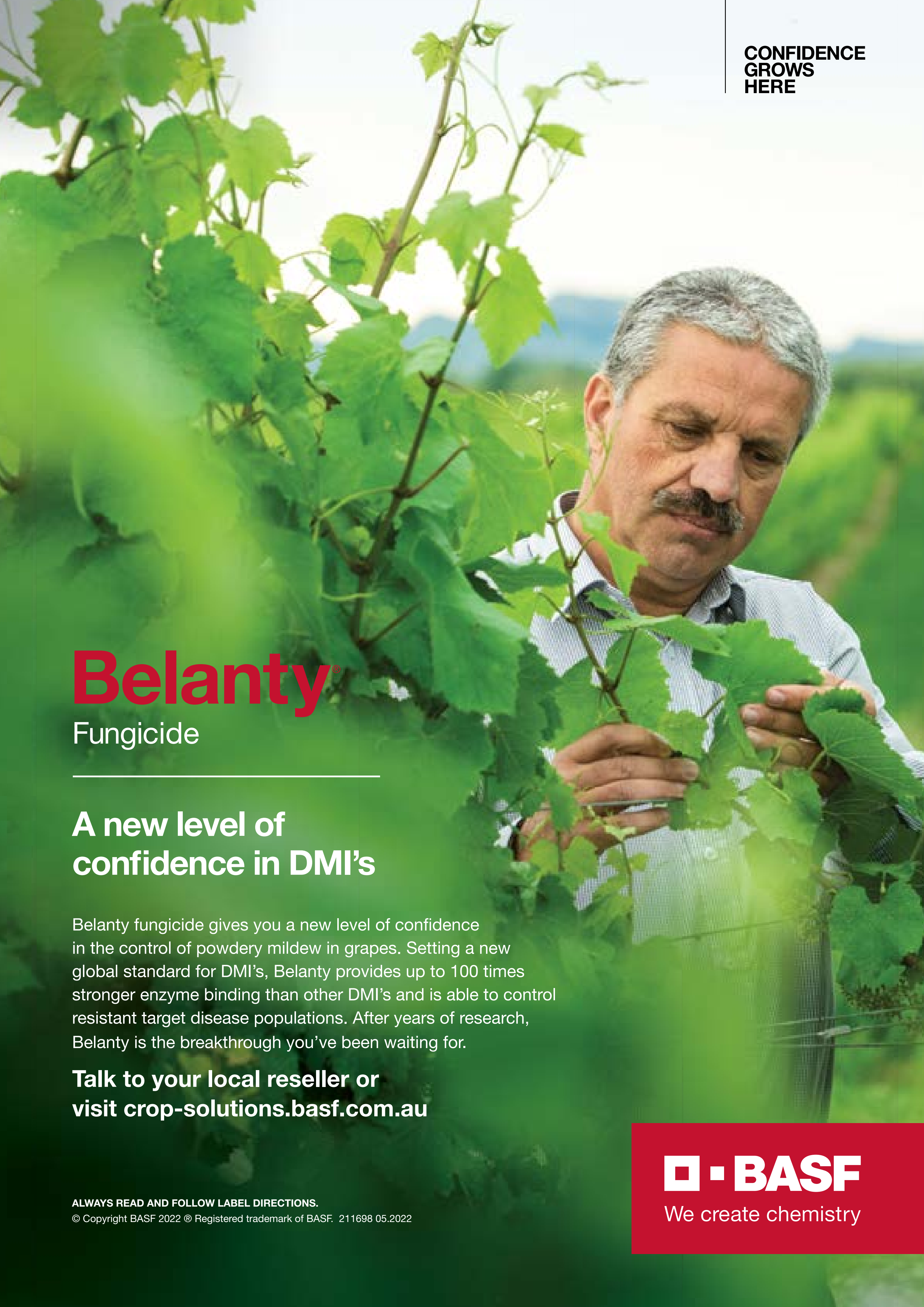
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mix of either wild-type or isolates with Y136F mutant and maintained in mini greenhouses. These leaves were shaken and rubbed around the tagged leaves. Plants were returned to the mini greenhouses and incubated for 48 hours to establish the infection. Two separate experiments were conducted for each *E. necator* population (sensitive and resistant).

After 48 hours of incubation in the mini greenhouses three DMI fungicides (Table 1) were applied both individually and mixed with sulfur using hand bottle sprayers. Plants treated with sulfur only were separated by at least seven metres from the other treatments to prevent fungicide vapour activity interference. The untreated control was sprayed with water.

Assessment of powdery mildew disease was conducted two weeks after fungicide treatment by measuring the percentage area of leaf infection. Each experiment was repeated using three biological replicates (plants), with treatments arranged randomly, and data was combined for repeated experiments and statistically analysed.

RESULTS AND DISCUSSION

Results showed that the untreated plants (no fungicide spray) had high disease severity (70% and 74% for sensitive and resistant populations, respectively). The results also showed that all DMI and sulfur combinations were very effective for both *E. necator* populations (wild type and with Y136F mutant), controlling the disease by between 98% and 100% compared with untreated controls under greenhouse conditions (Figure 2). There was no reduction in the efficacy of the three DMIs when mixed with sulfur to control powdery mildew. The results also demonstrated that the individual fungicides were equally effective at controlling powdery mildew, regardless of the presence of the Y136F mutant in the *E. necator* population.

Tank mixing with sulfur is a common practice to manage fungicide resistance as it provides more than one mode of action to control powdery mildew and other pests and diseases. Chivers *et al*. (2007) reported no antagonism between myclobutanil (Mycloss) and sulfur and the mix of sulfur and myclobutanil is an important tool to control Erineum mite (*Colomerus vitis*) and powdery mildew on grapes in New Zealand. Fungicide labels for Mycloss and Topas state that they are compatible with sulfur, and it has been recommended to mix sulfur with DMIs to manage resistance (Emmett *et al*. 2003). Although the resistant mix of *E. necator* has a high frequency of the Y136F mutant (linked to DMI resistance), Topas, Mycloss and Digger were still independently effective at controlling the disease. The resistance mechanism of DMIs are still not completely understood and Kunova *et al*. (2021) reported several mechanisms of resistance to DMIs, not only the Y136F mutant.

Table 1. Fungicides and application rates used in experiments.

Trade name	Active ingredients	Application rate (/100 L)
Topas®	100 g/L penconazole	125 mL
Mycloss®	200 g/L myclobutanil	16 mL
Digger®	250 g/L difenoconazole	25 mL
Thiovit Jet®	800 g/kg sulfur	200 g

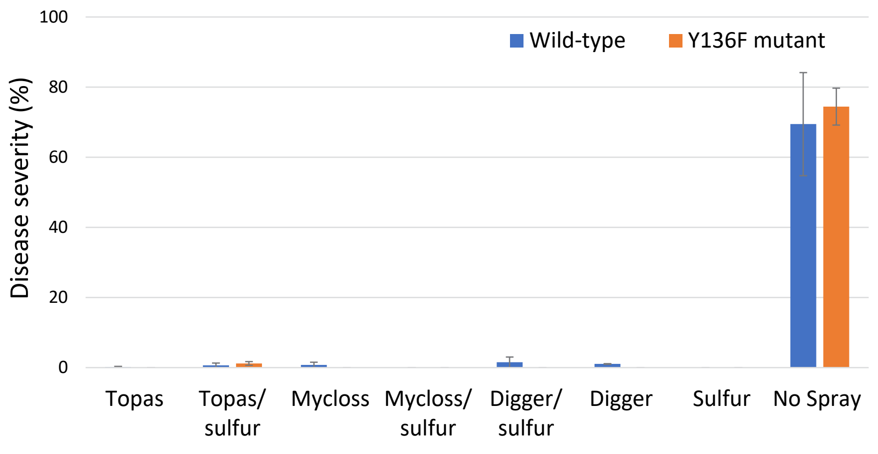

Figure 2. The effect of mixing sulfur with DMI fungicides on the severity of powdery mildew under greenhouse conditions using two *Erysiphe necator* populations; wild-type (blue) and with Y136F mutant (orange). Each column represents the mean of two individual experiments with three biological replicates. Bars represent standard error of the mean.

CONCLUSION

Tank mixing of DMIs and sulfur is an important strategy for the control of powdery mildew disease and to manage fungicide resistance in vineyards. This study confirmed that mixing sulfur with the DMIs Topas, Mycloss and Digger had no adverse effect on controlling powdery mildew.

ACKNOWLEDGEMENTS

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Development of an in-field molecular test to detect anilino-pyrimidine fungicide resistance in *Botrytis cinerea*

By Lincoln Harper[1], Fran Lopez-Ruiz[1], Scott Paton[2] and Mark Sosnowski[3,4]

Australian researchers have developed an in-field test that has proven to be rapid, simple and economical in detecting resistance to fungicides used to control botrytis.

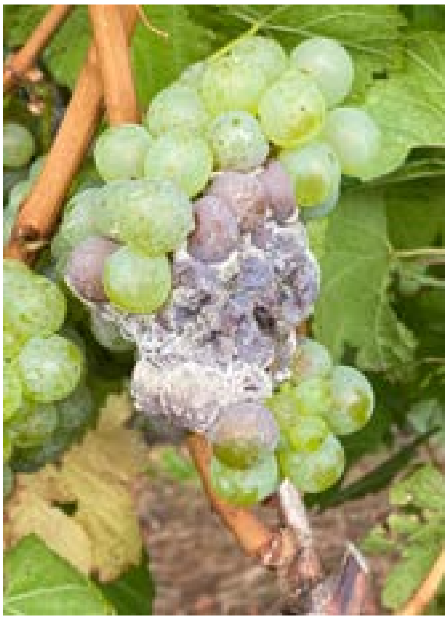

Figure 1. Botrytis bunch rot (photo courtesy of S. Paton)

INTRODUCTION

Botrytis bunch rot (BBR, Figure 1) is the second most economically important disease of grapevines in Australia behind powdery mildew (Scholefield & Morison 2010). The causal agent of BBR is *Botrytis cinerea*, with BBR and other bunch rots impacting all Australian grapegrowing regions, with an average cost of $50 million per annum to the grape and wine industry (Emmett *et al*. 1992, Scholefield & Morison 2010).

The main approach to control BBR in vineyards is through the routine application of fungicides (Elad *et al*. 2016). Due to the high reproductive rate and short life cycle of *B. cinerea*, development of resistance in this pathogen is highly likely if repeatedly exposed to the same fungicides (Brent & Hollomon 1998).

Determining the resistance frequency of *B. cinerea* is critical to developing adequate resistance management strategies for this pathogen. In general, time-consuming laboratory-based tests that characterise fungicide sensitivity, termed phenotyping, are widely used to determine resistance frequencies. A more rapid and cost-effective alternative to phenotyping is characterising resistance-associated mutations, termed genotyping.

Genotypic techniques are usually polymerase chain reaction (PCR) based methods, whereby a resistance associated DNA region is assessed for the presence or absence of DNA changes associated with resistance. However, these PCR-based techniques still require a combination of time-consuming methodology, expensive laboratory-based equipment and an experienced user. Therefore, adaption of genotypic techniques to a basic field-based process could provide quick *in-situ* assessment of resistance frequencies.

In-situ quantitative PCR (qPCR) has been previously shown to be a quick, robust and economical method for the assessment of QoI resistance in the wheat powdery mildew pathogen *Blumeria graminis* f. sp. *triciti* (Dodhia *et al*. 2021). qPCR is based on using a fluorescently labelled DNA binding probe to measure the amplification of a particular DNA region in real time. In the case of detecting fungicide resistance using this method, using two differently labelled probes in the same reaction (duplex assay) can allow a wild type (WT) or mutant DNA to be distinguished simultaneously. In Australian vineyards, fungicide mode of action (MOA) anilino-pyrimidines (AP, Group 9), such as cyprodinil and pyrimethanil, are a critical part of chemical programs for the control of BBR. In previous reports, the L412F amino acid change caused by the DNA change G1347T in the gene *pos5* have been shown to be associated with AP resistance (Mosbach *et al*. 2017, Harper *et al*. 2021). In our study, we have followed a similar approach for the assessment of QoI resistance in wheat powdery mildew to develop a qPCR assay for detection of the AP resistance-associated mutation L412F in a vineyard setting.

METHODS

Laboratory testing

To test *B. cinerea* infected plant material, a quick extraction DNA method was adapted from that used to process powdery mildew infected wheat leaf cores (Dodhia *et al*. 2021). To establish if this method could produce suitable DNA from infected berries for qPCR, frozen infected berries sampled from an experimental vineyard were placed in small tubes and hand ground in a quick extraction buffer using a micro pestle. The resulting slurry was diluted 100-fold in buffer and used as a template in qPCR.

A duplex assay was tested whereby both WT and L412F genotypes can be detected within the same reaction. A duplex assay system is more economical in terms of reagents and time, as less reactions are required per sample compared to a single target (uniplex) assay.

All testing was carried out using Sensifast Probe No-Rox mastermix (Bioline, U.K.) in a magnetic induction cycler (MIC) qPCR instrument (Biomolecular Systems, Australia). ▸

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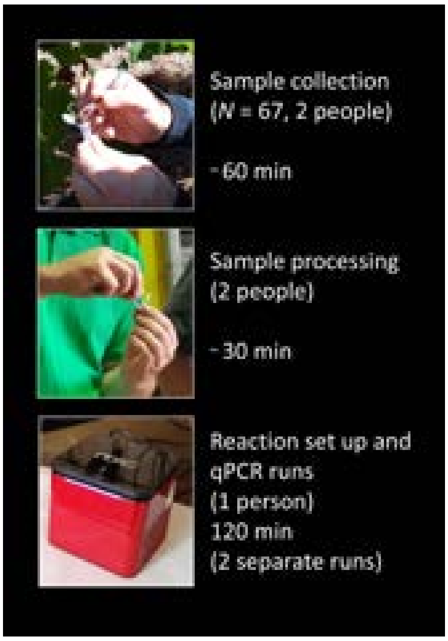

Figure 2. In-field qPCR pipeline for the testing of 67 samples from a 0.25-hectare block.

The assay was tested against pure *B. cinerea* WT or L412F mutant DNA separately to check for cross-reactivity between probes and non-target DNA. Pure DNA was also used to test mixtures of WT and mutant genotypes to see whether quantification of a low abundance target was achievable.

In-field testing

A quarter hectare block of Sauvignon Blanc near Margaret River was selected in February 2020 for in-field qPCR testing purposes. BBR was actively expressing throughout the block when sampling was initiated. To sample infected material, forceps were used to take infected berries and place them in tubes (Figure 2). A sample was considered as one infected berry taken from one bunch. A total of 67 samples were taken, with the row and panel noted for each sample. All sample processing and qPCR analysis was undertaken on-site. To enable a high throughput analysis of field samples only one technical qPCR replicate was tested. Two PCR runs were required to test all samples due to the machine limit of 48 reactions. Pure *B. cinerea* DNA was used as a positive control.

Figure 3. In-field L412F qPCR testing results for the Margaret River block. White circles indicate WT only. The red circle indicates L412F only. Yellow circles indicate the detection of WT and L412F DNA.

RESULTS AND DISCUSSION

Hand grinding one infected berry per tube, followed by dilution, provided adequate DNA for qPCR analysis. In the laboratory, the duplex assay was able to quantify separate samples of WT or L412F DNA, but not mixtures of WT and L412F DNA. Henceforth, for mixed genotype samples, each target would not be quantifiable, so only detection (yes/no) is currently possible. To be able to robustly quantify each target in mixed samples, further optimisation is required. This could include redesign of the assay components or running each reaction as a uniplex instead of a duplex.

The in-field testing of 67 samples identified three samples (5%) which had the L412F mutation (Figure 3). Two of the three positive samples had a mixture of WT and L412F DNA. Further in-field testing of other blocks could provide more information on the frequency and distribution of mixed samples. Blocks with high resistance target frequencies might be of interest to see whether mixed samples are still detectable under those conditions. Completion of the in-field testing of the 67 samples required approximately 3.5 hours for a team of two people (Figure 2). The time it takes for sample collection would vary depending on the ability to find disease and the number of samples taken. The minimum practical number of samples required to give reasonably representative frequency data is yet to be established. The number of samples taken would also affect the time for sample processing. Standard practice in laboratory qPCR runs is to include replicate reactions for each sample. In this in-field pipeline, running each sample once or in duplicate would affect the cost, the time to set up the PCR reactions and the number of PCR runs required. Each PCR run takes approximately 50 minutes.

CONCLUSION

In-field testing of the L412F qPCR assay showed that this current pipeline is a rapid, simple and economical means to detect resistance-associated mutations *in situ* within a vineyard setting. Approximate material costs for testing one sample in the in-field qPCR and phenotypic tests (Harper *et al*. 2021) are $5 and $1, respectively. However, this cost difference is easily compensated since obtaining results from phenotyping can take 10-14 days.

This pipeline could be of great use for initial screening at sites with potential control issues. Alternatively, this pipeline could also be of use for assessing resistance frequencies within chemical management trials, aimed at improving resistance management techniques.

Within a trial, the relationship between mutant frequencies and the frequency and timing of fungicide application, or even the removal of a fungicide MOA group, could be assessed. The production of adequate DNA from frozen infected berries also shows some flexibility at the sampling step; all infected berry samples could be harvested at one time and frozen for subsequent testing.

Further research is planned to expand assays to screen for other *B. cinerea* mutants for different MOAs and for other grape pathogens such as *Erysiphe necator* (powdery mildew). Future work will also investigate the use of the pipeline with DNA sourced from spore traps.

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Dormancy and cold-hardiness — two sides of the same coin?

By John Anthony Considine and Michael James Considine, School of Molecular Sciences and The Institute of Agriculture, The University of Western Australia, Perth, 6009, Western Australia*

Researchers from the University of Western Australia have investigated why latent grapevine buds are unable to resume growth in summer. Their findings could lead to better managing the effects of climate change in vines.

WHAT IS THE DORMANT STATE IN *VITIS*?

Our view of dormancy is drawn from practical horticultural science and seed biology. A seminal review of the topic was published in the *Australian Journal of Grape and Wine Research* by Shimon Lavee and Peter May (1997). However, we were prompted to take a fresh look at dormancy in the grapevine in a Doctorate of Science thesis written by Roger Pouget, undertaken near Bordeaux in the late 1950s and early 1960s. His observations conflict with the widely held view that chilling is related to dormancy, a conclusion acknowledged previously by Alan Antcliff and Peter May (1961) for Sultana.

Figure 1 represents our general view of a dormant grapevine. Typically, the viticulturist's only interest is whether the vine will grow or not. To assist in prediction, empirical models were developed based on chilling hour accumulation and heat summation. However, it seems that dormancy may not be just a winter phenomenon.

By the end of August (February in the Southern Hemisphere, SH), bud dormancy — as estimated by this test — is at its peak. Yet, it is summer. From that day forward until December (mid-June SH) dormancy declines. This is about the time that a heat degrees day model would start counting to estimate budburst. If one examines the climate data for that year and location, we can see that chilling is irrelevant with respect to the trends in resistance to budburst. The downturn in days to bud burst begins while day and night temperatures are relatively high (Figure 3, page 50).

What else happens that might explain the resistance to budburst and the apparent dormancy? Figure 4 shows the moisture content of a bud (data again from Pouget 1963). The onset of resistance to budburst is correlated with drying out of the bud — it begins to desiccate and its moisture content drops from slightly more than 80% to 45-50%. This, in turn, is correlated with an increase in freezing tolerance. It has been shown that short days are sufficient to induce stage I freezing tolerance in buds (c. -30°C) (Jones *et al*. 1999). Chilling, however, is required to induce stage II (c. -50°C). The beauty of the response is that it prevents ice propagation and cell damage (Jones *et al*. 2000). The bud is more resistant to freezing injury than the trunk which doesn't possess this mechanism.

IN BRIEF

- True dormancy in the grapevine is a late summer-autumn phenomenon and is initiated by shortening daylength.
- Dormancy is accompanied by the formation of a barrier and subsequent partial desiccation of the bud. This induces a high state of freezing tolerance in the bud. It is principally a physical not a physiological state of bud phenomenon.
- Quiessence is maintained by isolation not temperature or temperature-related changes.
- Chilling induces acclimatisation of the vine and does directly affect bud dormancy.
- Bud break is preceded by reactivation of the cambium and xylem and export of sugars from reserves into the xylem.

Figure 1. Dormant cv. Grenache vine growing in the Barossa Valley, South Australia. (Photo jac©).

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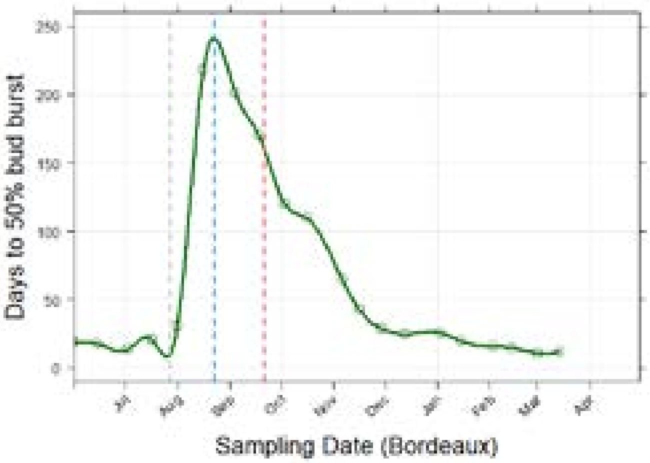

Figure 2. Dormancy as days in forcing conditions for cv. Merlot single-node cuttings taken from vines grown at Pont de la Maye, France. Dates are for the Northern Hemisphere (NH) and the vertical lines represent the start, the peak, and the autumn equinox. Redrawn from (Pouget 1963).

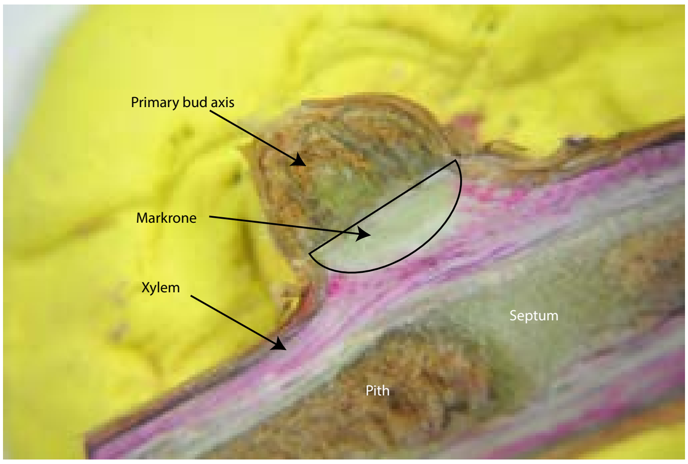

Figure 5. Cross section of a bud showing the presence of a 'block' of tissue – the Markrone – which prevents the movement of dye from the stem into the bud (Photo courtesy of Santiago Signorelli).

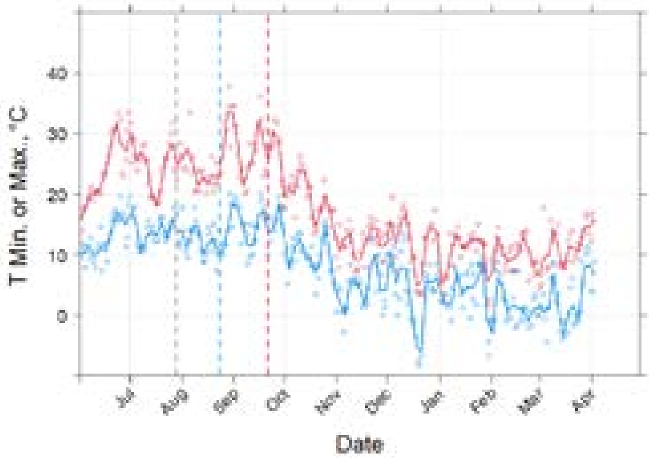

Figure 3. Temperature, minimum and maximum records for Pont de la Maye, France 1957/58. There is no evidence of any chilling that coincides with the start of the downturn in days to 50% bud burst. Refer to Figure 2 for legend.

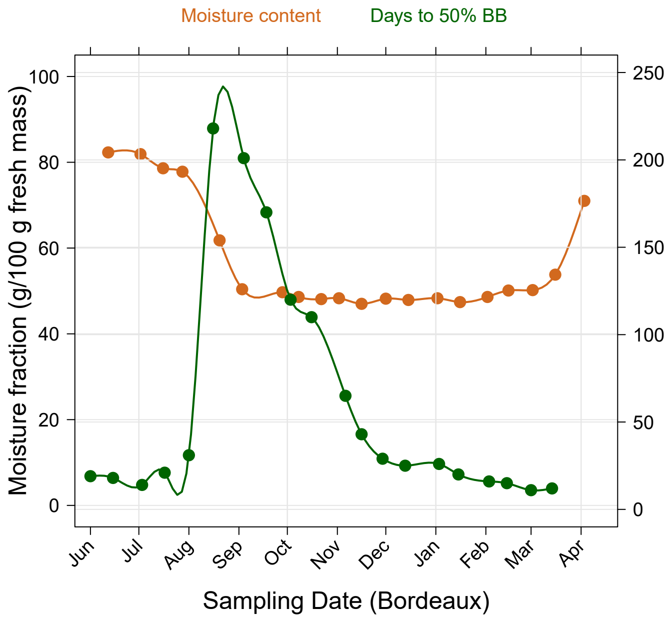

Figure 6. Daylength in hours—sunrise to sunset—for Bordeaux, France. The reference lines are as for Figure 2.

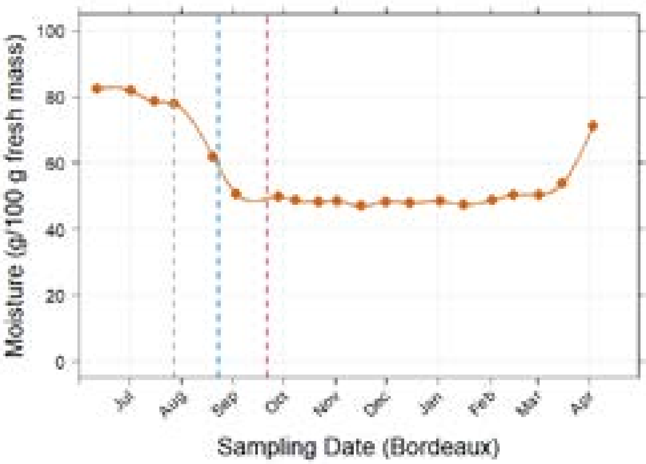

Figure 4. Moisture content of buds from July 1957 to June 1958 (redrawn from Pouget 1963). Otherwise as for Figure 2.

The cause of the desiccation lies within tissue at the base of the latent or dormant bud. This tissue is called a Markrone or crown and was discovered by a German botanist (Schröder 1869) but was largely ignored until recently (Figure 5). It undergoes profound changes that affect permeability to solutes and to water (Lee *et al.* 2017). A change in permeability immediately precedes bud burst (Signorelli *et al.* 2019, Meitha *et al.* 2018) and vascular development (Xie *et al.* 2018). Desiccation and suberisation of the bud scale and inner hairs also serve to protect the buds.

Figure 6 shows the trend in daylength for the location and reveals that only a small reduction is required to initiate the change. Critical daylength is generally considered to be between 13 and 14 hours. This also correlates with the table of the effect of summer pruning on budburst by Peter Dry and Richard Smart (in Lavee and May 1997) and with that of an earlier French scientist (Pierra Huglin 1958) and confirmed by work on other species of *Vitis* (Fennell and Hoover 1991). Previously, the buds were in a suppressed (quiescent) state achieved once about 10 primordial nodes had been developed. This story is made more

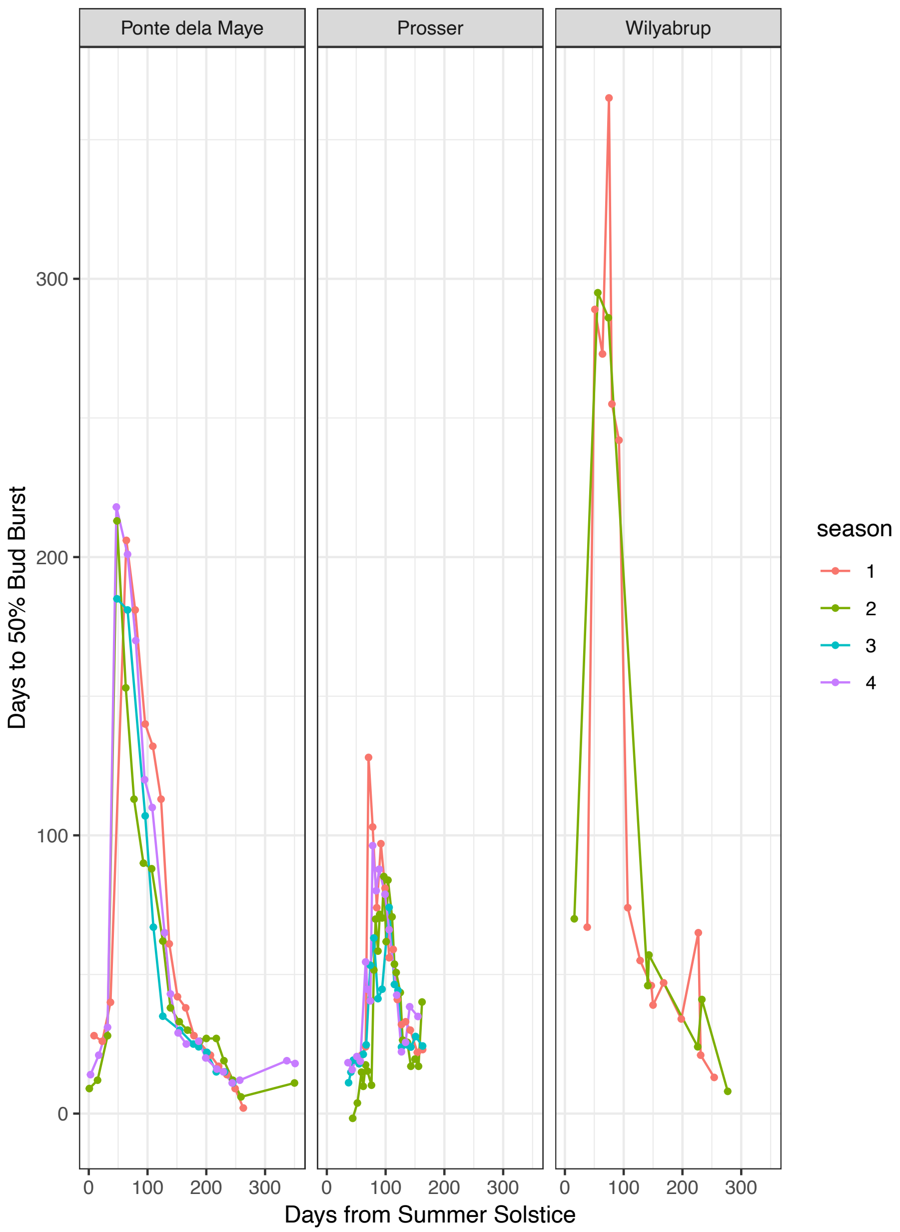

Figure 7. Days to 50% budburst for Cabernet Sauvignon grown in three regions. Data for Pont de la Maye (Pouget 1963); Prosser (Camargo Alvarez *et al*. 2018) and Considine *et al.* (unpublished).

convincing by other data presented by Roger Pouget and by Jacques Nigond (1961) on the synchronous nature of entry into the 'resistant state' — all buds up to at least node 10 become dormant at the same time (the buds of a higher order may not have finished development), almost as if someone flicked a switch.

So, what is dormancy in the grapevine? In winegrape cultivars such as Merlot and Cabernet Sauvignon, the buds transition from 'quiescence' to dormancy. As usually defined, the transition prevents growth while the Markrone develops, and the bud becomes semi-isolated and acquires resistance to freezing injury. Once that state is achieved, the buds lose their 'dormant' state but remain 'quiescent' because of their isolation and desiccation (Figure 2). Certainly, the buds develop a new state, but that state has little to do with temperature and little effect on metabolism within the bud (Veleppan *et al*. 2022). This means that buds maintained for long periods at forcing conditions may simply starve to death because they have access only to the limited resources present in the bud itself.

What does temperature, particularly chilling, have to do with dormancy in the grapevine? It may have no direct influence, serving only to deepen the state of chilling resistance and induce a degree of cold tolerance in the trunk and shoots. Indeed, leaf abscission has a substantial role inducing 'dormancy' of the phloem which appears blocked by callose (Pouget 1963), a sugar polymer that is impermeable. An even earlier study by Katherine Esau demonstrated that callose removal in budburst is correlated with the control of budburst of more basal buds by the apical bud, apical dominance (Esau 1948). If chilling does not affect dormancy, then is it necessary? Will loss of chilling conditions through climate change be material, of itself? Possibly not, simply that the rate of transition may be enhanced as thermal hours increase and bring budburst and maturity forward. This has implications for vine cultivation in a warming climate and in warm regions.

GENETIC AND CLIMATIC INFLUENCES ON DEPTH OF 'DORMANCY'

Little is known of the importance of the degree of resistance to budburst, but growers understand that there are differences. Cabernet Sauvignon is well-known as a late cultivar and one that exhibits budburst characteristics akin to those of Merlot, while Chardonnay and many tablegrapes are prone to early budburst and, consequently, frost risk. Location has a profound effect on resistance to budburst. In Figure 7, the two coastal locations, Ponte de la Maye (Bordeaux) and Willyabrup (Western Australia), show a similar extreme while the continental site of Prosser (Washington State, USA) shows less resistance despite experiencing a much colder climate.

Data for a wider range of cultivars and locations shows a similar diversity, the nature of which is not known (Figure 8). However, there is a general correlation with the site of origin. Those originating from regions close to the centres of diversity in central east Asia/Europe and Mediterranean Europe generally show a high degree of resistance to budburst, while those derived from central or eastern proles, developed for table eating by Muslim communities in Southeast Asia, show low resistance to budburst (the so-called eastern prole). That is the block at the Markrone seems readily resolved.

CONCLUSIONS

Dormancy in the grapevine is complex. It does not appear to be a chilling-related phenomenon, at least at the level of the bud. The apparent dormancy observed is induced by shortening days and is uninfluenced by temperature. The bud becomes partially isolated from the supporting shoot, desiccates to a degree, and becomes resistant to freezing injury and ice propagation — an autumn frost tolerance mechanism. Chilling is related, together with photoperiod to other changes, to cessation of shoot extension, accumulation of reserves, leaf fall and overall frost resistance. Onset of budburst is preceded by a change in the porosity and permeability of the Markrone and by vascular development. It is also proceeded by sap flow (Glad *et al*. 1992). With sap flow and rehydration of the bud comes progressive loss of frost tolerance.

Thermal influences on the corpus or body of the vine may be material in determining budburst and release from what was thought to be a simple process. We should shift our focus from the bud to the whole plant. Developing a detailed understanding of the actual processes, undistracted by terms such as 'bud dormancy', may guide us towards a better understanding of the plasticity of the grapevine to climate and, thus, to climate change. Perhaps 'acclimatisation' and 'de-acclimatisation' may be terms that more accurately describe the processes involved in the transitions of physiological state than those presently used: dormancy, eco-dormancy, paradormancy and endodormancy.

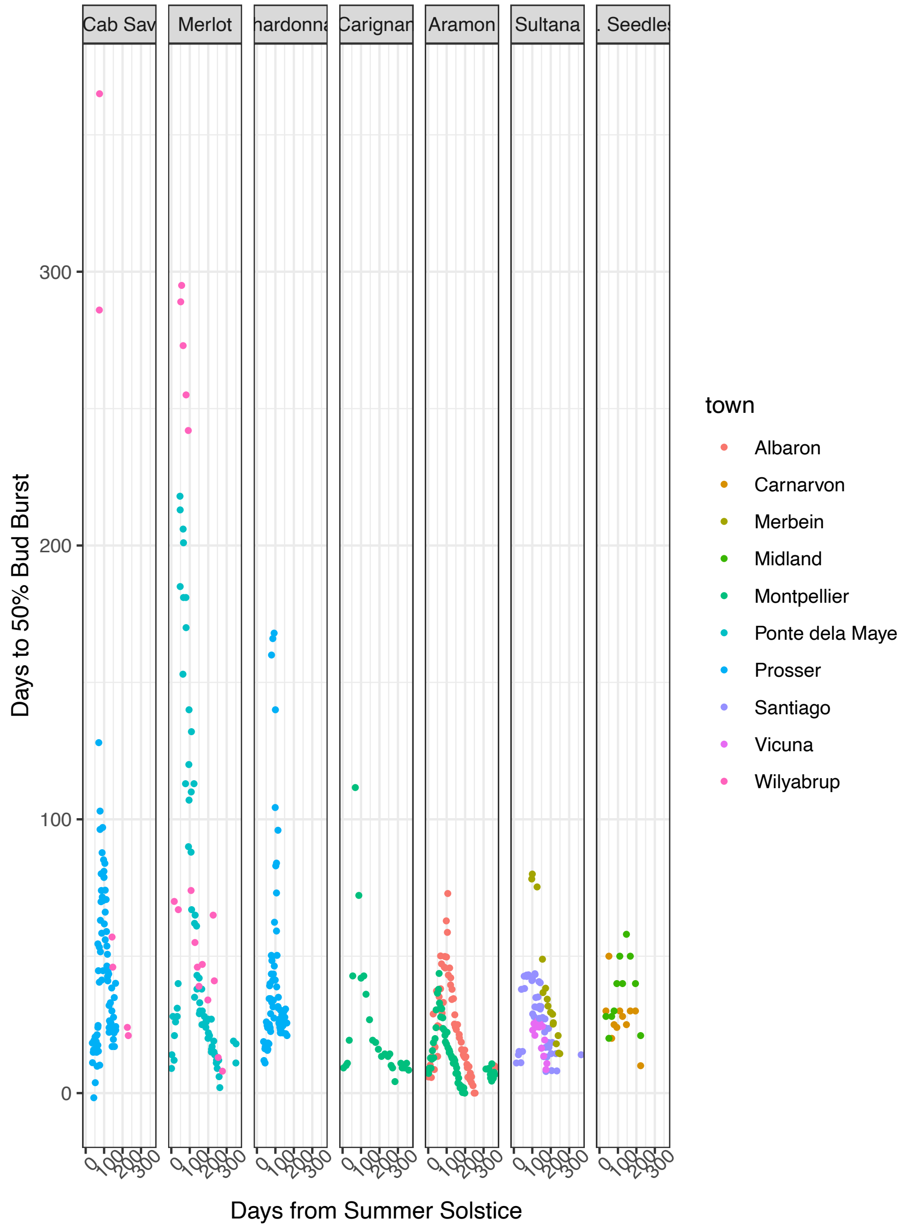

Figure 8. Data for seven cultivars and 10 locations show something of the diversity of degree of summer dormancy. Various sources. Includes the data from Figure 6. The other sources are available from the authors.

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Underpinning terroir with data

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Grapegrowing and winemaking are increasingly data-driven activities, supported by an ever-growing array of digital technologies and record management systems for tasks such as yield estimation, irrigation management, fruit payment and wine marketing. Digital information on soils, topography and climate is also increasingly available. Recent research has explored the use of such data along with spatial analysis techniques typically used at the within-vineyard scale, to underpin improved understanding of regional terroir.

IN BRIEF

- **Terroir zoning has traditionally relied on classical approaches to land classification and expert opinion about wines and has been constrained by historically delimited geographical indications (GI) and/or appellation boundaries.**
- **Using examples from the Barossa Zone, Margaret River and Marlborough (NZ) GIs, this article demonstrates how a more data-driven approach might promote improved understanding of the biophysical component of terroir.**
- **Coupling such work with wine sensory and chemical analysis may also enable the grape and wine production process to be optimised and assist in demonstrating the distinctiveness of Australian terroirs.**

INTRODUCTION

Australian geographical indications (GI) are primarily associated with wine provenance and label integrity and are not generally used to evoke local terroir. However, there is increasing interest amongst winemakers and marketers in using the notion of the 'uniqueness' of Australia terroirs (Wine Australia 2015) as a marketing tool. In some regions, this interest has expanded to exploring whether the identification of sub-regions within our GIs can contribute to the perception of distinctiveness, and whether this might be related to a local terroir.

Terroir as a concept reflects the many factors (Dry 2017, Van Leeuwen *et al.* 2020 and references in both) that, at any location, impact on grapegrowing and/or winemaking and give a wine its 'sense of place' (Goode 2005). However, much of the previous research into terroir, relating to both the relative impact of its component factors and terroir 'zoning', has arguably been constrained by a mixture of reliance on traditional approaches to land classification, the boundaries of historically defined regions or appellations, qualitative expert opinion of wines, heuristics, and inadequate consideration of questions of scale (Bramley 2017, Bramley *et al.* 2020, Brillante *et al.* 2020). New quantitative methods of sensory and spatial analysis, coupled with the increasing availability of digital soil, terrain and climate information, present opportunities for overcoming such limitations. Furthermore, Australia's GI system has a recent history and is not impacted by the sort of local 'rules' governing production, as are common in many Old World countries. We therefore have an opportunity to explore our understanding of terroir so that, in addition to being better informed about issues such as sub-regionalisation, we might also be able to improve the management of our wine production systems so that the wines we produce are, more assuredly, the ones that we and our markets want to consume. In this article, these ideas are illustrated through three recent examples from the Barossa (South Australia) and Margaret River (Western Australia) regions of Australia, and from Marlborough in New Zealand. A common thread in these examples is the use of methods of spatial analysis more typically used to underpin understanding of within-vineyard variability and the development of Precision Viticulture, albeit applied at the regional scale. Note that this article only seeks to provide summaries of this work; readers interested in more detail, especially of the methods used, are encouraged to access the source articles.

SUB-REGIONALISATION IN THE BAROSSA ZONE GI

The Barossa Zone GI (Figure 1), henceforth referred to in this article as 'the Barossa', comprises the Barossa and Eden Valleys, which are defined as 'regions' within the GI, and the 'sub-region' of High Eden. However, through its 'Barossa Grounds' project, the Barossa Grape and Wine Association (BGWA) has been exploring sub-regional variation in wine style and terroir, with particular focus on Shiraz wines, with a view to seeing whether further sub-regions might be justified. In this connection, they have identified three distinctive 'Grounds' (https://barossawine.com/wp-content/uploads/2017/12/Barossa-Chapters-Grounds.pdf) within the Barossa Valley region - the 'Northern', 'Central' and 'Southern Grounds', with two smaller grounds, 'Eastern Edge' and 'Western Ridge', also acknowledged. The identification of these grounds is derived in part from a thematic mapping analysis (Robinson and Sandercock 2014) and from a sensory analysis of local wines conducted by local winemakers. A key element of the Robinson and Sandercock (2014) study was the input of a local viticultural technical committee which classified the range of soil available water capacity (AWC), annual rainfall (AnnR), season growing degree days (GDD)

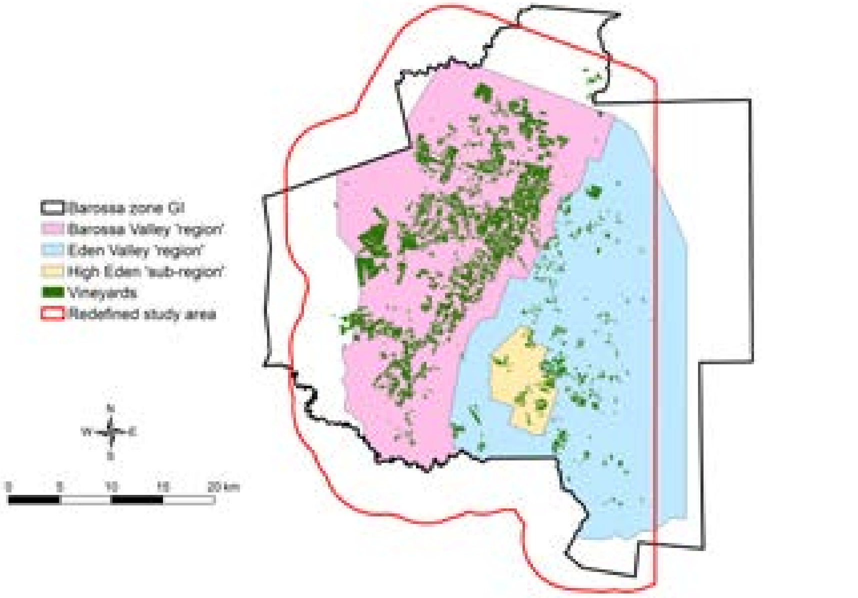

Figure 1. The Barossa Zone GI comprises the regions of Barossa Valley and Eden Valley and the High Eden sub-region. Also shown are the locations of vineyards (courtesy: Vinehealth Australia) and a redefined boundary used for the work described here. Data of Bramley *et al.* (2020).

and elevation into categories of perceived viticultural significance. This was a complex task given the marked soil variability within the GI and the fact that, of 61 soil types identified in a 1:50,000 soil survey of South Australia (Hall *et al.* 2009), 33 were found to exist within the Barossa. Even after the aforementioned classification of AWC, AnnR, GDD and elevation, 147 of the possible 600 category combinations were found to occur within the GI. When the analysis was confined to just AWC and elevation, 21 unique classes were still identified within the GI. Clearly, the suggestion that the Barossa be subdivided on this basis was unlikely to be practical.

It is important to note here that there is no suggestion that the Robinson and Sandercock (2014) analysis was somehow flawed. Rather, their analysis, albeit using classical land classification approaches, highlighted the complexity within the GI. It is perhaps for this reason that the sensory analysis conducted by the local winemakers appears to have been the primary justification for the identified 'Grounds'. Again, it is not suggested here that this was flawed, although it does seem highly probable that the ability of local winemakers to discriminate wines within their own region is different to that of the average consumer.

The recent availability of biophysical data in digital format, such as the Soil and Landscape Grid of Australia (SLGA; Grundy *et al.* 2015), along with data available from the Australian Bureau of Meteorology (BOM), provides a means of re-considering the classical approach to terroir analysis and zoning. In a preliminary analysis, Bramley *et al.* (2020) obtained SLGA data for AWC and soil cation exchange capacity (CEC; a surrogate indicator of soil fertility) at 90m resolution. Because these soil properties showed similar patterns of spatial variation throughout the region down the soil profile, depth-weighted mean values (5-60cm) were used to characterise soil variation. They also acquired meteorological data (long-term averages based on at least 30 years) from SILO, a national database maintained by the Queensland Government in partnership with BOM, for AnnR, growing season rainfall (GSR), mean growing season temperature (GST), mean January temperature (MJT) and GDD. In addition, an elevation model derived from the Space Shuttle Radar Topography Mission (SRTM) was obtained. All of these 'base' data (Figure 2) were re-sampled to the same 1ha map grid (i.e. 100m x 100m) generated using a boundary for the study area (Figure 1). Note that this boundary was modified from the GI boundary to enable more climate data to be included in the analysis and because much of the land to the east of the GI is highly unlikely to be developed for viticulture.

A statistical method known as '*k*-means clustering' was then used to group the data layers shown in Figure 2 so as to identify areas in the GI which show similarity in their patterns of spatial variation – in exactly the same way that those interested in

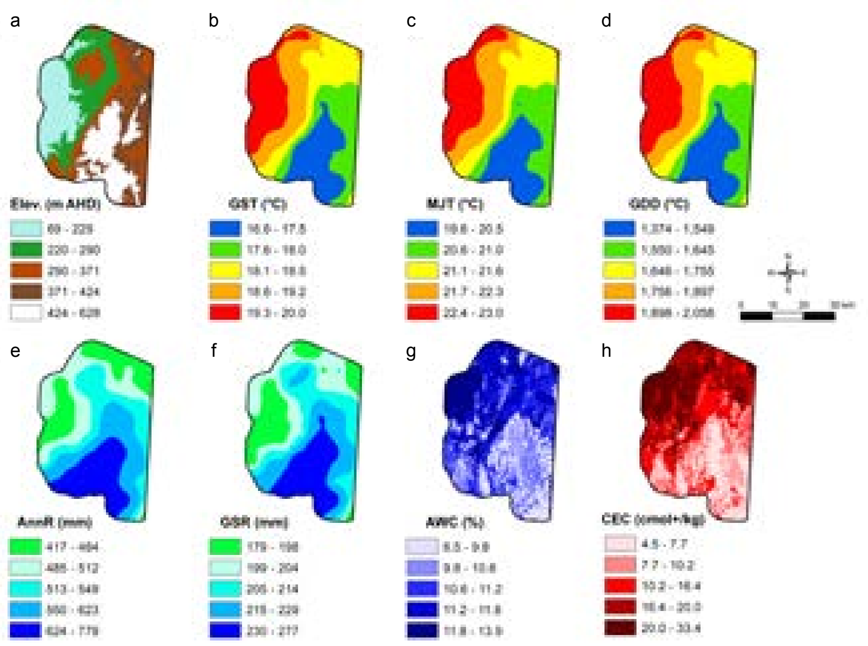

Figure 2. Base data layers used for analysis of biophysical variation in the Barossa Zone GI. (a) Elevation (Elev); (b) mean growing season temperature (GST); (c) mean January temperature (MJT); (d) season growing degree days (GDD); (e) annual rainfall (AnnR); (f) growing season rainfall (GSR); (g) soil available water holding capacity (AWC) in the 5–60cm depth increment (profile-weighted mean); and (h) soil cation exchange capacity (CEC; 5–60cm). All data have been classified based on the 20th percentiles to facilitate identification of patterns of variation. Data of Bramley *et al.* (2020).

Precision Viticulture have identified so-called 'management zones' within individual vineyard blocks (e.g. Bramley 2017). Unsurprisingly, when the temperature indices (GDD, MJT, GST) were clustered, they identified a temperature gradient running southeast-northwest and delineated the cooler Eden Valley and warmer Barossa Valley. Clustering of GSR and AnnR similarly separated the wetter Eden Valley from the drier Barossa Valley. The two valleys were also distinct in terms of AWC and CEC with the Barossa Valley being characterised by more fertile soils with greater water holding capacities than the less fertile Eden Valley soils – presumably largely a consequence of soil clay content. When these soil properties (AWC, CEC) were clustered along with GDD and GSR as a characterisation of the viticultural season, the result was a simple splitting of the Barossa and Eden Valleys (Figure 3a); no further sub-division (i.e. additional clusters) was justified based on this analysis.

The result shown in Figure 3a is a 'whole of region analysis' using data covering the entire GI (Figure 2). As such, it is consistent with most previous terroir zoning research, including the Robinson and Sandercock (2014) study. Yet careful analysis of Figure 1 shows that only about 10% of the Barossa land area is under vine; that is, we should only consider this 10% of the land area when analysing wine terroir since the rest of the land area is not supporting winegrowing. Accordingly, a revised analysis was undertaken (Bramley and Ouzman 2022) but just for land under vine. (Note that this more recent analysis also used an updated climate dataset, but its spatial structure was almost identical to that seen in Figure 2b-f). This led to a more substantial separation within the GI – seven clusters (Figure 3b) instead of just two. The two valleys were again separated, but within the Barossa Valley a more marked delineation was seen. In particular, the northwesternmost areas appeared to separate largely on temperature, but in the strip of land which lies immediately to the west of the range which separates the Barossa and Eden Valleys, there was greater delineation; this strip of land was consistently identified across several analyses involving different combinations of soil and climate attributes.

It seemed likely that topography might be important to the variation within the GI. Accordingly, in Figure 4, a further cluster analysis is shown in which, in addition to the attributes included in Figure 3b, slope (Sl) and aspect (fN) – which are readily determined from the elevation data (Figure 2a) – were also included. The result shown in Figure 4 clearly separates the cooler, wetter Eden Valley, whose vineyards tend to have steeper slopes and aspects within 90° of north, from the rest of the GI. But within the Barossa Valley there are three clusters of vineyards which separate on their slope and aspect; indeed, the yellow and green clusters in Figure 4 appear to separate only on slope, aspect and AWC, whilst the vineyards on the flattest land immediately to the west of the hills which divide the Barossa and Eden Valleys are the least fertile (based on CEC as a surrogate measure of fertility) and also experience a cooler season than the remainder of the Barossa Valley.) It is suggested that Figure 4 would be a useful starting point for examining differences in grape and wine chemistry and wine sensory characteristics as a basis for gaining a better understanding of the terroir of the Barossa Zone GI (Bramley and Ouzman 2022). Note that Figure 4 contrasts somewhat with the 'Barossa Grounds' proposed by BGWA (https://barossawine.com/wp-content/uploads/2017/12/Barossa-Chapters-Grounds.pdf).

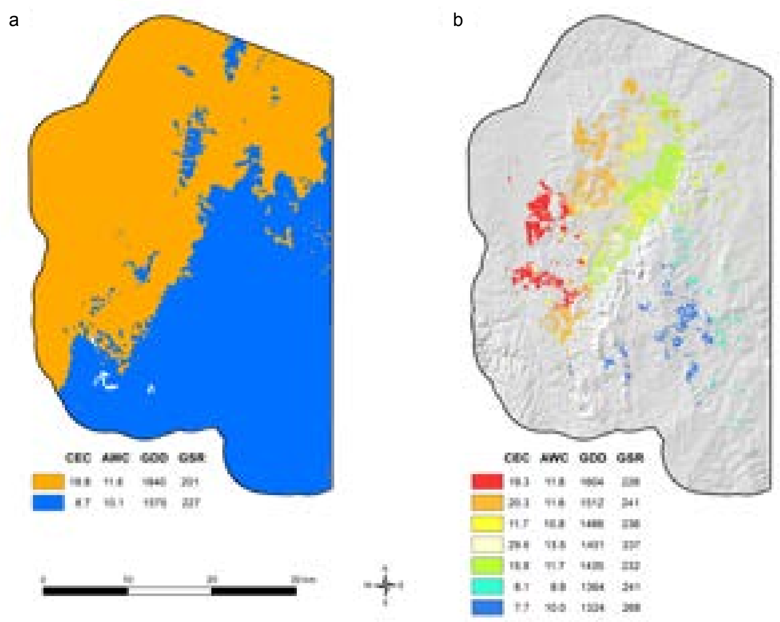

Figure 3. Results of clustering soil properties (cation exchange capacity, CEC; and available water capacity, AWC) with indicators of the viticultural season (GDD, season growing degree days; GSR, growing season rainfall) in the Barossa using data for either (a) the entire GI land area (data of Bramley *et al.* 2020), or (b) just land that is under vineyard (data of Bramley and Ouzman 2022). The numbers in the legends are cluster means. The hillshade in (b) derives from the elevation model (Figure 2a).

SUB-REGIONALISATION IN THE MARGARET RIVER GI

Like their counterparts in the Barossa, Margaret River producers are also interested in gaining a better understanding of their terroir. In this respect, there has been much recent media coverage of a proposal to establish Wilyabrup as a sub-region within the Margaret River GI. The study reported below (Bramley and Gardiner 2021), which followed a similar approach to that followed in the Barossa, was not specifically conducted to underpin, test or otherwise disrupt the Wilyabrup proposal, although it is suggested that it could usefully inform consideration of its merits. Rather, the objective was to promote understanding of terroir variation in the Margaret River region more broadly.

Margaret River (Figure 5a) covers a much larger land area (2125km^2) than other premium Australian wine regions. For example, the Barossa and Eden Valleys (Figure 1) cover approximately 1170km^2 between them, or just over half the area of Margaret River, while McLaren Vale covers just 471km^2. However, whereas around 10% of the land area in the Barossa is under vine, less than 3% of the Margaret River GI is planted to vineyards. As in the Barossa work, a dataset was assembled covering soil, climatic and terrain data; broadly, these were the same as those used in the Barossa study and were obtained from the same sources. In addition, the soil content of coarse fragments (CFG) was also included in the analysis as this is considered viticulturally important in the gravelly soils which are common in the region. Once again, the data were projected onto a 1ha map grid which enabled the same kind of cluster analysis of the various map layers to be conducted as was done in the Barossa study; Bramley and Gardiner (2021) provide further details.

When the analysis was conducted for the entire region (Figure 5b), nine clusters were identified, but interpreting them proved to be difficult. Preliminary clustering of just the temperature indices indicated a temperature gradient running through the GI in an approximately northeast-southwest direction. The Swan Coastal Plain to the north was identified as markedly warmer than the coastal area to the southwest of the GI, south of the town of Margaret River. Likewise, the north

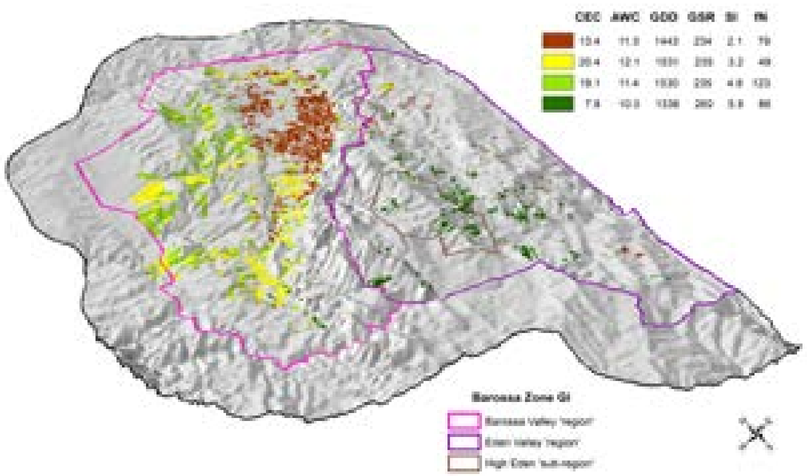

Figure 4. Results of clustering selected soil properties (CEC, soil cation exchange capacity; AWC, soil available water capacity), climate indices (GDD, season growing degree days; GSR, growing season rainfall) and topographic attributes (SI, slope; fN, aspect, expressed as degrees from north) for land under vineyard in the Barossa using k-means. The data have been draped over the digital elevation model (Figure 2a) from which the hillshade was derived. Note that in this map, elevation has been exaggerated by a factor of eight relative to the horizontal, and that the position of the north arrow is approximate only. Numbers in the legend are cluster means. Data of Bramley and Ouzman (2022).

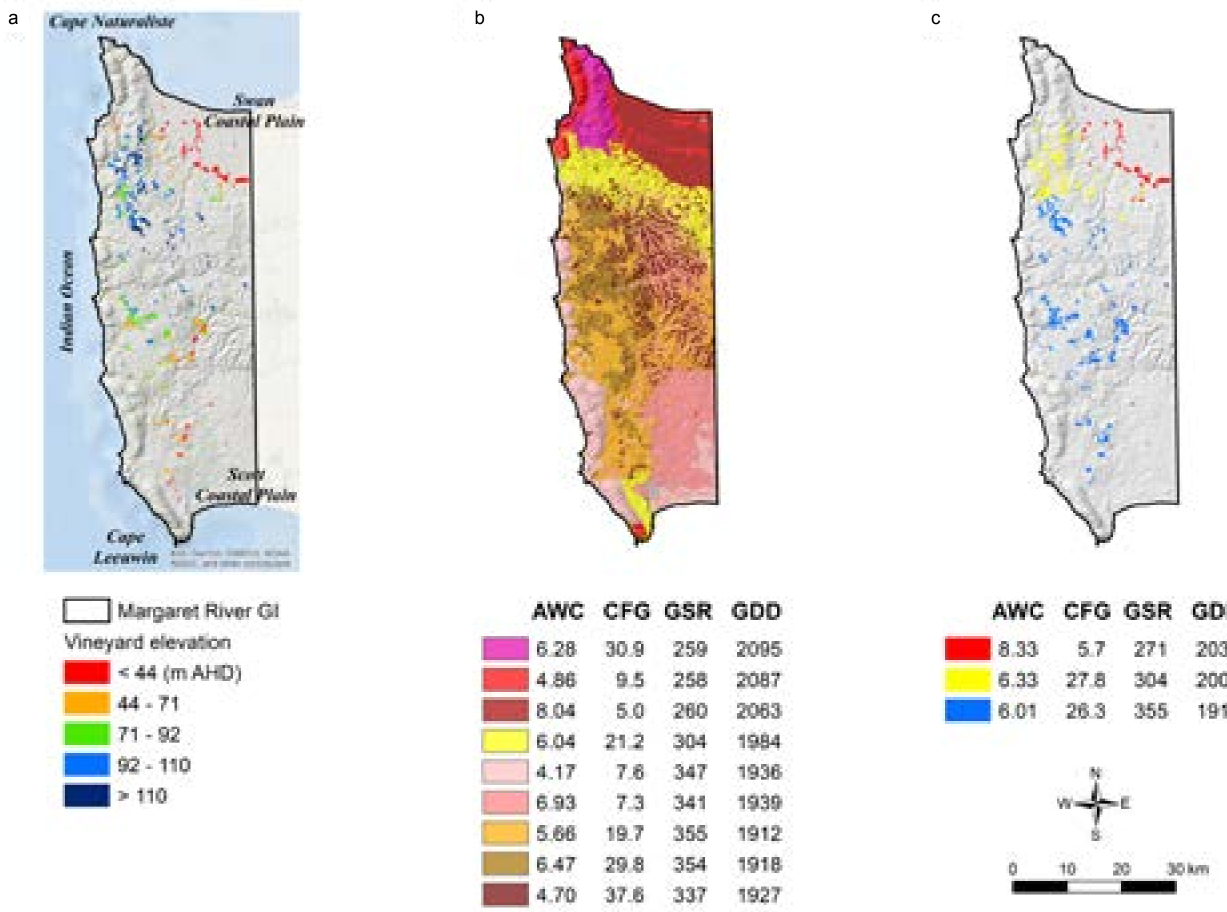

Figure 5. Variation in soil properties, climate indices and elevation in the Margaret River region when considered regarding (a, c) land under vineyard, or (b) in the entire GI. In (a), the data have been classified into 20th percentiles; in (b, c) the numbers in the legends are cluster means. The hillshade derives from the elevation model (not shown). Data of Bramley and Gardiner (2021).

is drier than the south in both annual and growing season rainfall. Clustering of soil data alone also identified the Swan Coastal Plain as distinct from the rest of the GI, but the patterns of soil variation in the remainder are highly complex and occur over short distances, reflecting the impact of drainage and elevation on patterns of variation in this ancient landscape. However, as can be seen in Figure 5a, except for vineyards on the Swan Coastal Plain, Margaret River vineyards do not occupy locally characteristic elevations and none of the soil clusters identified by Bramley and Gardiner (2021) aligned closely with sub-regions that had previously been proposed by either Gladstones (1999) or Lacorde (2019). Overall, as can be seen from Figure 5b, Margaret River is a highly complex landscape in terms of its patterns of variation.

When the cluster analysis was repeated for just the land under vineyard, a somewhat simpler picture emerged; again, the Swan Coastal Plain vineyards appear distinct from the others. Otherwise, it is clear that Margaret River vignerons have a preference for more gravelly soils. However, because these gravelly soils occur throughout the GI, the main separation identified by the cluster analysis is one based on growing season temperature and rainfall. This finding should not be used to infer that soil variation is not important in Margaret River; on the contrary, there is good evidence in support of the view that it is critical to vineyard-scale management. But in terms of sub-regional terroir, it appears that its short-range variation is too complex to enable readily identifiable and locally distinct sub-regions to be delineated. Figure 5c has been proposed as a sensible basis for a chemical and sensory analysis of Margaret River wines with a view to further understanding distinctiveness within the region (Bramley and Gardiner 2021).

VARIATION AMONGST THE SAUVIGNON BLANC VINEYARDS OF MARLBOROUGH, NZ

In contrast to the Barossa and Margaret River studies which relied on publicly available data and, thus far, have included neither wine sensory nor chemical data, nor measures of vineyard performance, in this Marlborough study (Bramley *et al.* 2020), our starting point was measures of vineyard performance that are commonly collected as part of the yield estimation and recording process. Indeed, the work was originally done to inform the deployment of a sensor currently being developed to aid early season yield estimation. Given the likely logistical constraints associated with using a sensor over a wide area at key phenological stages, it was of interest to know if a yield estimate made in one location could inform an estimate required for another. However, as will be evident below, the analysis has potentially important implications for terroir.

When yield mapping is used as a part of Precision Viticulture, a yield monitor fitted to a harvester logs yield (typically at 1Hz) and the data are then interpolated into a yield map using a geostatistical process known as 'kriging'. In this work, we treated the Marlborough region as though it were a single vineyard; the many wine companies that donated data to this work were collectively regarded as though they were a yield monitor. Thus, for the seasons which ended with vintage in 2014-2019, we collected

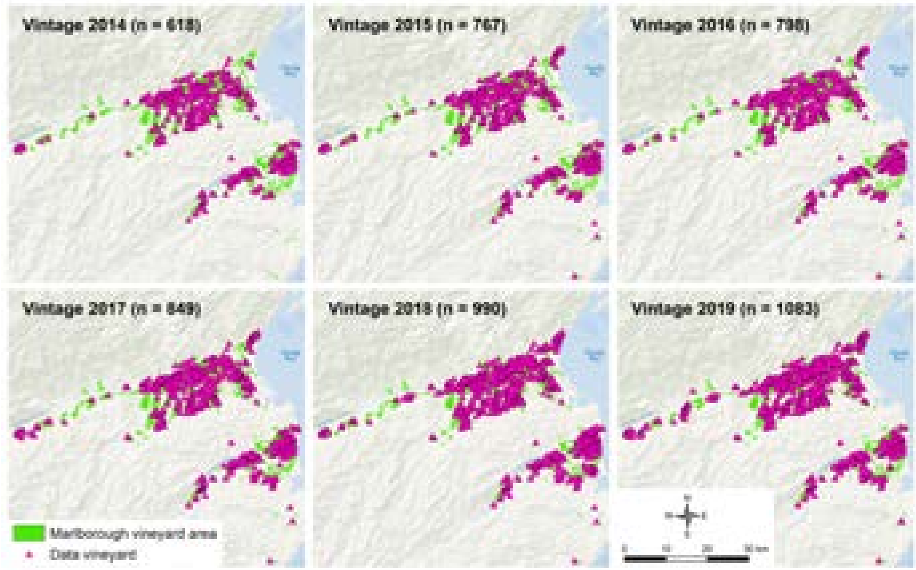

Figure 6. Distribution of data collected to underpin regional-scale mapping of the yield of Sauvignon Blanc in the Marlborough region, 2014-2019. Also shown is the Marlborough vineyard area defined based on a map layer provided by the Marlborough Regional Council. The basemap layer was sourced from ESRI (Redlands, CA, USA) and its collaborators through the ArcGIS software. (v.10.7.1).

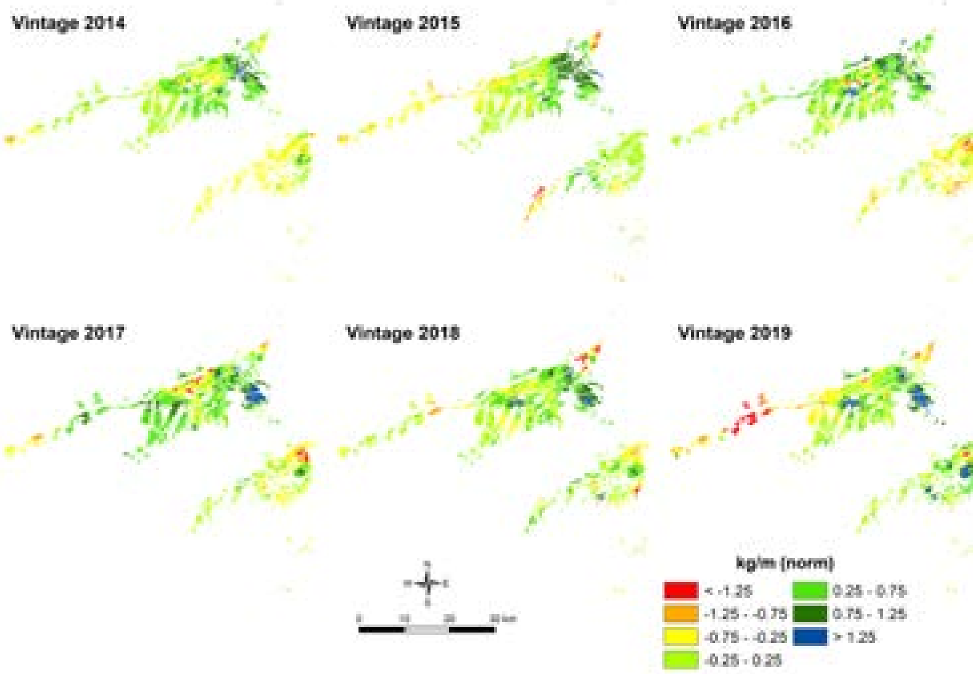

Figure 7. Regional scale variation in the yield (kg/m) of Marlborough Sauvignon Blanc, 2014-19. Note that the data have been normalised (mean = 0, standard deviation = 1) prior to map interpolation.

Table 1. Analysis of differences between yield-harvest date zones when based on raw vineyard data for yield (kg/m) and harvest date (Day; Julian numbers) from locations corresponding to the clusters identified in Figure 9A.

Cluster	2014			2015			2016			2017			2018			2019		
	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day
4	172	4.39b	91.3s	202	2.88b	85.4r	208	4.30b	94.9r	226	3.55c	92.6s	220	3.50bc	81.5s	221	3.12c	80.1s
1	73	5.31a	97.5qr	97	3.73a	94.5pq	94	5.05a	104.5p	105	4.70a	100.7r	152	4.64a	90.8qr	116	4.25a	87.2r
5	56	4.27bc	94.4rs	103	2.62c	92.2q	113	4.46b	100.6q	107	3.96b	103.4q	112	3.36cd	91.9q	119	3.19c	85.9r
2	89	3.67d	98.9q	134	2.76bc	94.4pq	142	3.43d	100.1q	159	3.03d	102.1qr	158	3.14d	89.4r	168	3.09c	90.0q
3	88	3.82cd	104.9p	124	2.74bc	95.9p	125	3.80c	107.1p	131	3.48c	108.6p	130	3.77b	95.7p	129	3.65b	96.3p

[A]For any individual year, yields and Julian days marked with different letters are significantly different ($p<0.05$). n denotes the number of data values in each cluster.

yield records for 600-1100 Sauvignon Blanc vineyard blocks, all georeferenced to the centroid of their block (Figure 6). The data were then interpolated into regional-scale maps of yield (Figure 7) and harvest date (Figure 8). The yield data were expressed as kg/m to remove the effects of different vineyard configurations and were then normalised on a per season basis (mean of 0, standard deviation of 1) to remove the effects of differences in weather between seasons. Harvest dates were converted to Julian numbers to enable mapping.

As can be seen in Figures 7 and 8, despite marked inter-annual differences in weather which impacted on crop phenology and the average regional yield, the patterns of spatial variation in both yield and harvest date are remarkably stable over the six years of the study. Thus, when all the map layers in Figures 7 and 8 were clustered together, some potentially important sub-regional differentiation became clear (Figure 9, page 60). First, the Awatere Valley to the south of the Marlborough region is clearly lower yielding, and yet tends to be harvested later than the Wairau Valley to the north. Most likely this is a temperature effect given the expectation that, at any given location, a lower yielding crop might otherwise be expected to ripen and be harvested before a higher yielding crop. Incorporation of climate data into the analysis, as was done in the Barossa and Margaret River studies, will enable this to be assessed and is the subject of a current study. Within the Wairau Valley, three main clusters emerge. The red cluster (Figure 9) has an approximately average yield and is harvested the earliest. Interestingly, this is the part of the Marlborough region which was developed first for viticulture. The pale green cluster is quite variable (Figure 9), without much consistency from year to year, whereas the dark green cluster, also clearly evident in the yield maps (Figure 7) closely aligns with an area of much siltier soils which presumably have higher water retention than the more gravelly soils which predominate in the GI. Again, further

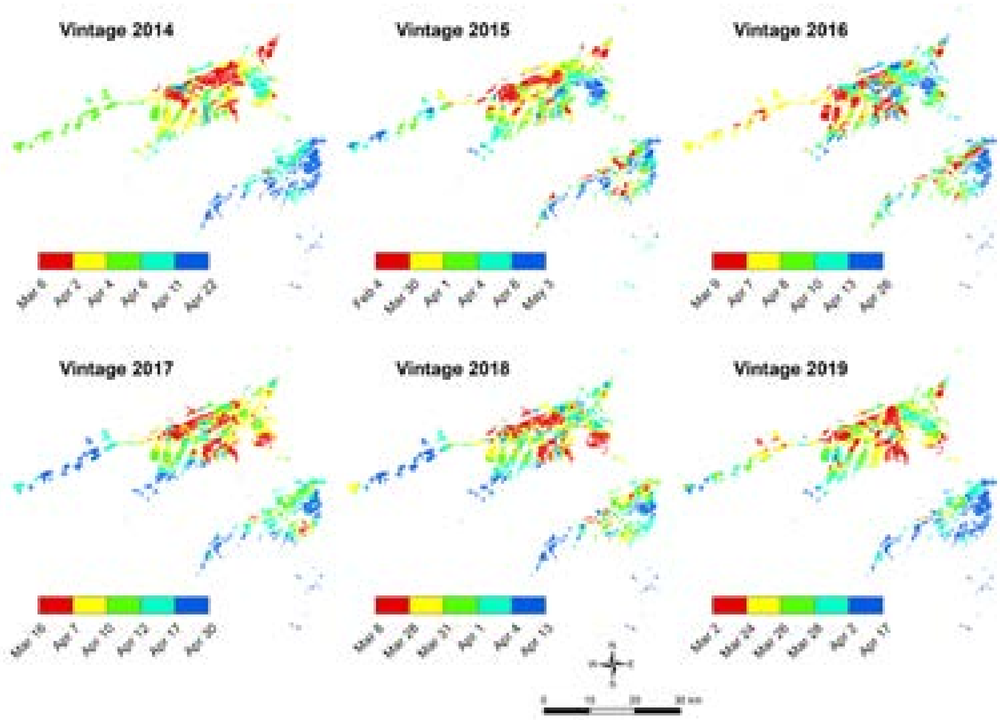

Figure 8. Regional scale variation in the date of harvest of Sauvignon Blanc in the Marlborough region, 2014-19. In each map, the data have been classified such that 20% of the data lie in each coloured class. The first date in each legend is the date of the earliest harvest recorded in the dataset for that year. The last date listed is the latest date of harvest for that year, whilst the other dates are those that divide the map classes.

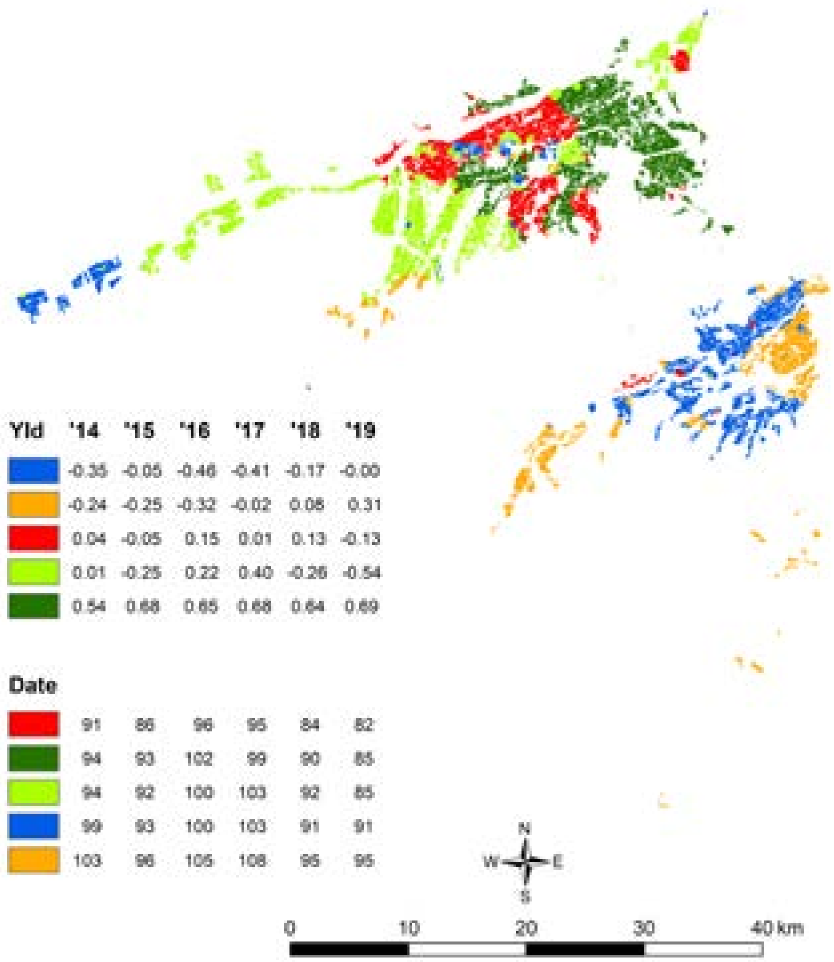

Figure 9. Results of clustering maps of yield (Figure 7) and harvest date (Figure 8) from each of the 2014-19 vintages using *k*-means. The numbers in the legends are the cluster means; in the case of yield (kg/m) the data were normalised (mean = 0, standard deviation = 1) prior to map interpolation, whilst harvest dates are expressed here as Julian numbers. Note that the yield and harvest date legends are displayed separately to aid interpretation; there was a single cluster analysis of yield and harvest date together. The colours assigned to the different classes are not necessarily intended to infer a particular characteristic of the clusters. However, an attempt at sensibly ordering the legends has been made.

Table 2. Differences between the Wairau and Awatere Valleys in terms of yield (kg/m) and harvest date (Day; Julian numbers)[A].

Region	2014			2015			2016			2017			2018			2019		
	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day	n	Yield	Day
Wairau	351	4.47a	94.4q	202	2.94a	90.3q	466	4.38a	99.5q	508	3.78a	98.4q	547	3.74a	87.5q	536	3.38a	84.5q
Awatere	127	3.75b	102.4p	456	2.87a	94.2p	214	3.68b	102.6p	218	3.35b	104.6p	223	3.51b	92.0p	216	3.43b	93.5p

[A]For any individual year, yields and julian days marked with different letters are significantly different ($p<0.05$). n denotes the number of data values from each valley

analysis incorporating soil data, as was done in the Barossa and Margaret River studies, will be used to confirm this hypothesis.

The 'kriging' map interpolation process results in a lot of data smoothing, especially with relatively low density data such as used in this study. Consequently, the contrast between the apparent Marlborough sub-regions (Figure 9) might strike some people as minor. However, when the differences between the sub-regional clusters is evaluated using the 'raw' vineyard data as opposed to the maps alone, there are many statistically significant differences (Table 1, page 60). Also of interest here is the fact that, even if the spatial analysis is ignored and a simple comparison is made between the Wairau and Awatere valleys, there are some statistically significant differences between them (Table 2, page 60). Clearly, Marlborough has a varied terroir.

BEYOND SPATIAL ANALYSIS

Several contrasts and similarities exist between these three studies, each of which point to obvious ways of taking them forward. So far, none of them have included wine chemical or sensory analysis. However, the various cluster solutions (Figures 4, 5c and 9) offer an obvious starting point for examining differences in the chemical and sensory properties of wines produced in these different GIs. In the case of the Barossa, a current Wine Australia-funded project is doing just that with the results to be reported presently. Analysis of the wine sensory and chemical data independently of other attributes will also enable assessment of the degree to which any identification of sub-regions based solely on wine attributes aligns with the one shown here based on soil and climate data. Likewise, it is understood that the Margaret River Wine Association will be pursuing similar

investigations of wine sensory and chemical alignment to the biophysical variation in the region.

Second, whereas the Barossa and Margaret River studies presently rely solely on biophysical data that are publicly available, they do not incorporate any measures of vineyard performance such as those which underpin the Marlborough study. Collecting these kinds of data is a large and complex task which also requires careful management of privacy issues. On the other hand, as the Marlborough example shows, it can be done. Whether there would be an appetite amongst Australian producers for contributing such data remains to be tested, but one possible avenue would be to use the various vintage surveys that are currently conducted, along with Wine Australia's national vineyard scan (https://www.wineaustralia.com/research/projects/national-vineyard-scan) as a means of facilitating this. Such a strategy, along with expansion of the data collected to include indices of the quality or value of production, could potentially inform various decisions related to the optimisation of our wine production systems, including what variety to grow where. Alignment of such analyses with data available in the Climate Atlas (Remenyi *et al.* 2019) may also promote consideration of the climate change impact on terroir (Brillante *et al.* 2020). Similarly, incorporation of soil and climate data into the Marlborough analysis (currently under way) seeks to enable the yield and harvest date variation to be more meaningfully understood in the context of the Marlborough terroir.

Whichever way these studies evolve, by utilising modern methods of spatial analysis, all of them provide data-driven platforms which are free of heuristics and the effects of prior perceptions of our vineyard regions and the boundaries of their GIs, to promote a better understanding of Australian terroir and the distinctiveness of our wines. As discussed by both Bramley and Gardiner (2021) and Bramley and Ouzman (2022), there are good reasons why the marketing benefits of all this may be minor, albeit that they may allow us to tell stories about wine that are true and based on science rather than mythology. But the real value in truly understanding terroir from a data-driven perspective lies in the opportunity it generates for optimising our winegrowing management systems – at both vineyard and regional scales (Brillante *et al.* 2020).

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Koen Janssens, from Bink Wines.

All the way with Alicante Bouschet

By Koen Janssens, Bink Wines, South Australia

THE BACKGROUND

Alicante Bouschet, or Alicante Henri Bouschet, has been widely grown since it was first cultivated by French viticulturist Henri Bouschet in 1866. It is a cross between Petit Bouschet and Grenache. The Petit Bouschet grape (itself a cross of the very old variety Teinturier du Cher and Aramon) was created by Henri Bouschet's father Louis Bouschet. The result was a grape with deep colour and of higher quality than Teinturier du Cher. Several varieties of Alicante Bouschet were produced of varying quality.

The variety's high yields and easy maintenance encouraged its popularity among French wine growers, especially following the phylloxera outbreak that ravaged the nation's vineyards in the late 1800s. By the end of the 19th Century, there were Alicante Bouschet plantings in Bordeaux, Burgundy, Loire Valley and Alentejo in Portugal.

In the latter half of the 20th Century, Alicante Bouschet developed a reputation for producing uninspiring wines that lacked varietal distinction. Modern producers in Europe are working hard to change people's perception of the variety and prove that, when grown properly, it is capable of making great wine that is fruity, fresh and balanced. However, its ability to ripen and produce large

Alicante Bouschet

By Peter Dry, Emeritus Fellow, The Australian Wine Research Institute

BACKGROUND

Alicante Bouschet (ahlee-KAHN-tay boo-shay) is a red-fleshed variety that was the result of hybridisation from the mid-19th century in the south of France. The full name is 'Alicante Henry Bouschet' but it is usually known as 'Alicante Bouschet'. Henri Bouschet crossed Grenache Noir and Petit Bouschet (Aramon Noir x Teinturier) — the resultant progeny named 'Alicante Henry Bouschet' and 'Alicante Bouschet numbers 1, 2, 5, 6, 7, 12 and 13' were subsequently released. Vineyards today are a mix of 'Alicante Henry Bouschet' and 'Alicante Bouschet number 2' (distinct but similar siblings). Synonyms include: Alicante, Dalmatinka (Croatia), Garnacha Tintorera (Spain), and Kambusa (Bosnia and Herzegovina). The global area in 2010 was 39,000ha (approximately doubled since 1990). The largest area is in Spain (52%), where more than half is found in central Castilla La Mancha. There is also a large area in Galicia. In France (13% of global area) it is mostly grown in the south, mainly in Herault where it is permitted to be used — unlike other red-fleshed hybrids with American Vitis parentage. It is also grown in Portugal (9%), Italy, Turkey, Hungary, Croatia, Cyprus and elsewhere. Outside of Europe, the largest areas are in Chile (11%), USA (California), Argentina, Uruguay, Algeria and Morocco. Alicante Bouschet was introduced to Australia in the 1960s but there are currently only 10 or so wine producers (Barossa Valley, Margaret River, Riverland, Eden Valley, Adelaide Plains, North-East Victoria and Hunter Valley).

VITICULTURE

Budburst is early and maturity early to mid-season. Vigour is moderate with semi-erect growth habit. Bunches are medium to large and well-filled to compact with medium berries with red pulp and dark red juice. Yield is moderate. It is pruned to spurs and reported to be heat tolerant. It is susceptible to downy mildew and bunch rot, but less so to oidium, and has low resistance to wind.

WINE

Alicante Bouschet is generally regarded as a low-quality variety in most regions of the world because its wine lacks character. It is mainly used to add colour in blends; however, its value as a colour enhancement variety is limited by the instability of red pigments in finished wine. One of the few places in the world where Alicante Bouschet wines are looked on more favourably is the hot Alentejo region in southern Portugal where it has been used for varietal wines.

For further information on this and other emerging varieties, contact Marcel Essling at the AWRI (marcel.essling@awri.com.au or 08 8313 6600) to arrange the presentation of the Alternative Varieties Research to Practice program in your region.

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crops very early in the season can come at the expense of alcoholic strength.

ALICANTE IS A TEINTURIER

Teinturier (meaning to dye or stain in French) varieties are red winegrapes that have dark skins and flesh, whereas most red winegrapes have dark skins and clear flesh. The colour of the flesh of Teinturier varieties is caused by anthocyanin pigments accumulating within the pulp of berries as opposed to being confined to the outer skin tissue. The juice squeezed from Teinturier varieties is red, whereas in most dark-skinned grape varieties the juice is clear.

Recognised by many today as a noble red variety (particularly in southern Iberia), Alicante Bouschet is known for its deep dark colour. Under specific conditions, the grape can produce high yields of up to 80 hectolitres per hectare. The grapevine is thought to be prone to grape diseases like anthracnose, downy mildew and, occasionally, bunch rots in rare instances where bunches are tight at harvest. Alicante Bouschet leaves turn a beautiful purple hue in late autumn.

THE VINES

The block of Alicante Bouschet in Tanunda, in the Barossa Valley, that I source fruit from was grafted on Pedro Ximenez in the early 1990s. The vineyard still has an 'old school' planting system where vines are two metres apart and rows are four metres apart. The vineyard is just over two acres in size. Running north-south, the block is planted on a heavy sandy soil with loam deep underneath.

The block always delivers an amazing crop — generous bunches between 275g and 350g — and a good canopy. Producing multiple bunches per cane, I like to spur prune this block knowing that the vine will grow lots of canopy (it's super vigorous) and fruit. It also gives me the opportunity every year to have a balanced and equal distribution of energy through each vine and good protection from the sun without creating an environment where humidity (read: powdery and downy) can thrive.

THE WINE(S)

As a lover of obscure varieties, the opportunity to make Alicante Bouschet in 2020 was a no-brainer. A winery had made a killer Alicante Bouschet that I was able to try a couple of months beforehand. This made my decision to make one even easier.

Ripening Alicante Bouschet grapes in the Barossa Valley vineyard that provides the fruit for Bink Wines.

The Alicante Bouschet block (like all of my blocks) are hand harvested simply to minimise damage to the variety which loves to stain everything. 2020 was a difficult year with heatwaves during the latter stages of the growing season. I was unaware that Alicante Bouschets can be quite blunt sometimes (I had one ferment that was entirely destemmed fruit and it was pretty average). Having whole bunch ferments in the mix that year produced a wine that was as good as I thought I could make it. It was super bright with loads of red berries, tart fruits, purple florals and the smell of fresh cut hay. What was very notable from the beginning is that the fruit tasted very ripe on the vine but always came in with a low Baume and ended up low in alcohol.

Bink Wines Meisje Alicante Bouschet is made from 100% Alicante Bouschet — 50% whole bunch, 50% destemmend fruit — which is fermented dry on skins and aged in seasoned French oak.

The following year, 2021, was a god's blessing — good rainfall in winter, no crazy weather conditions during the growing period, good flowering with again no extreme climate conditions, the stars aligned. I pulled a lot of fruit off the block that year so I was able to experiment quite a bit with Alicante Bouschet — some 100% whole bunch, some layered ferments, some shorter ferments, some extended ferments. The end result made me smile and realise what Alicante Bouschet is (and for me) always will be — a really good table wine, a conversation starter, a wine you can bring to a BBQ or to a roast, a wine that can sit after the white wine section in a degustation menu but can also star as the pièce de résistance; just very versatile.

Learning that Alicante Bouschet really loves old large format oak, I was able to put the wines in 500L puncheons to further develop the red berries and floral structure. Unfortunately, we got hit with hail just after flowering in the growing season of 2021-22. The block took a serious hit and I lost about 70% of the crop. The remaining fruit had some scars but nothing major (thank you canopy!). I made a 50/50 ferment with whole bunch clusters underneath and destemmed fruit on top. The wine is looking very promising this year — bright and lifted. I'm very excited because the general consensus is that 2022 is better than 2021 in the Barossa Valley. Time will tell. WVJ

(ADVERTORIAL)

Imtrade CropScience continues to lead the way in the baiting game

It has been two years since Imtrade released its dual baiting system Transcend®, combining the molluscicide Metaldehyde and the insecticide Fipronil. Imtrade CropScience South Australian and Victorian state sales manager and bait product manager John Barbetti could not be more pleased with the product saying, “Metakill®, our snail and slug bait, already had a strong customer base so Transcend has offered additional value to existing customers whilst also opening up new markets for those just chasing insects”.

The dual bait controls snails, slugs and a range of insect pests and is a testament to Imtrade’s R&D efforts, filling a gap in the bait market. The weather resistant bait offers a vast improvement in the protection of beneficial insects over a boom or aerial applied broad-spectrum insecticide.

“Transcend’s registration now extends to a range of horticulture cropping situations, including use in grapevines, and has been widely adopted by growers broadly across Australia,” Barbetti said. He added, “We’ve been in the bait market for 20 years, starting out with a bran-based, low-concentration metaldehyde formulation, but discovered over time that effective control required more baits per m^2, higher active concentration and durability. Our research findings drove us to develop a solution for insect, snail and slug control in a single bait”.

“To maximise control, growers and agronomists need a quality bait, longevity in wet and dry conditions, high palatability to target pests and high efficacy. These combined attributes allow a single bait to deliver an effective lethal dose multiple times. The bait dimensions and application rate are key to maximising likelihood of encounter, especially with snails and slugs,” Barbetti said.

“European earwigs, Portuguese millipedes and three different species of slaters are associated with significant grapevine damage in many regions across Australia,” he continued. “To have the ability to incorporate the control of all these pests within existing snail and slug control management plans in a single application has major economic savings for growers, with the added benefit of contributing to carbon reductions on farm and the ability to be incorporated into integrated pest management programs.

“We’re extremely proud to deliver another market-leading product to Australian growers from a 100% Australian owned company,” Barbetti said.

The opportunities and challenges of building the Australian wine category in India

By Justin Cohen, Senior Marketing Scientist, Ehrenberg-Bass Institute for Marketing Science, University of South Australia

On 2 April 2022, Australia and India signed the Australia-India Economic Cooperation and Trade Agreement that will see tariffs on wine substantially reduced when it comes into force in the second half of this year. Justin explores how Australian wine exporters can address this opportunity and some of the challenges of the Indian market.

The Australian wine sector has an opportunity with the recent signing of the Australia-India Economic Cooperation and Free Trade Agreement. Until we (hopefully) repair our relationship with China, there is scope to focus on the Indian market as a home for some of our surplus wine. As we navigate out of COVID-19, the Australian wine industry needs to reinvest in key markets like the US, Canada and the UK as well as the European, Nordic, Middle-Eastern and Asian markets. Nevertheless, the excitement about the Australia-India Economic Cooperation and Free Trade Agreement warrants an article to help our industry plan how to address this opportunity and manage some of the significant challenges.

THE POTENTIAL OF INDIA

India is the second largest population in the world. According to Statista (2022), the Indian market consumed about five billion litres of alcohol in 2020. While this is expected to grow due to rising income levels among its population, India has experienced a recent decline in consumption due to COVID-19 related to lockdowns and bans on the sale of alcohol (Statista 2022). The long-term prognosis is good as 88% of Indians under the age of 25 claim to have purchased or consumed alcohol despite the cultural taboos and limitations on advertising and restricted buying in some parts of the country (Statista 2022.)

Although India's total volumetric measure of consumption is vast, it is important to grasp that 92% of that consumption is spirits, followed by beer; wine only accounts volumetrically for about 1% of all alcohol consumption in the market (Statista 2022). Furthermore, Bhardwaj (2021) reports that 70% of wine consumed in India is domestically produced. Whilst exports of Australian wine to India increased by 71% by volume and 81% by value in 2021 (McNaught 2022), we are still only playing in a third of that single percentage point of all alcohol consumption.

The runway for growth is enormous. However, we do have a significant challenge to increase the penetration of the wine category in India. We need a strategy to help fit wine more generally into the lives of Indian alcohol drinkers and become part of the repertoire of consumption of the primarily spirit and beer drinking population. We can do this by trying to understand the category entry points for wine and, more broadly, the spirits and beer category so we can work on ways to orientate and communicate how wine can fit into Indian consumers' lives. Cohen *et al.* (2019, 2020) illustrated how we did this in the China market through the support of Wine Australia. There is opportunity for us to work with the Indian wine industry to try and achieve this. Category growth is good for everyone. The industry needs a market development strategy based on Sharp's (2010) principles of mental and physical availability because making Australian wine easier to think about and easier to find will help us achieve sustainable growth in the Indian market.

NAVIGATING THE BAN ON ALCOHOL ADVERTISING

According to Bhardwaj (2021), India has banned advertising of the alcohol category since 2000. I interviewed Shardul Ghogale, the former head of export and travel retail at Sula Vineyards, a prominent Indian wine business, and current global director of sales at Left Coast Estate. He explained the loopholes that many of the larger alcohol brands utilise, conducting surrogate advertising where these brands launch other product categories that

HOW THE AUSTRALIA-INDIA ECONOMIC COOPERATION AND TRADE AGREEMENT WILL AFFECT WINE

- **Tariffs on wine with a minimum import price of US$5 per bottle will be reduced from 150% to 100% on entry into force and subsequently to 50% over 10 years (based on Indian wholesale price index for wine).**

- **Tariffs on wine bottles with a minimum import price of US$15 will be reduced from 150% to 75% on entry into force and subsequently to 25% over 10 years (based on Indian wholesale price index for wine).**

they can advertise across all media channels without restriction to try and build their brands. Ghogale spoke of examples of alcohol brands launching bottled water, energy drinks and other adjacent categories. Some brands have even gone as far as launching completely unrelated categories.

If an Australian wine brand is serious about being a large brand in India, a strategy of building reach in the marketplace will be required. If exploring how to utilise surrogate marketing most effectively, my suggestion would be to focus, if possible, on a complimentary category with high penetration. All communications must have strong branding with a focus on building distinctive assets so that potential buyers will notice wine with the same branding when they are in a purchasing environment. Cohen (2020, 2021) talks more about how to effectively utilise and build distinctive assets.

Bhardwaj (2021) suggested that the main marketing options for most brands are limited to wine tasting events, trade shows and festivals. Ghogale explained that another popular way for alcohol brands to advertise was to sponsor music events and Bollywood award shows. His observation was that wine brands have been lacking on that front. Perhaps as India navigates its way out of COVID-19 and these events become more common there is scope for Australian brands to get involved.

Some lesser understood loopholes are that alcohol brands seem to be able to have brand pages and post content on platforms such as Facebook and YouTube. It seems that if brands don't put any paid advertising behind their content or posts that this is tolerated by the regulators in India. According to Sharma (2016), the regulations in India have yet to properly address digital channels. Whilst this may be a possible option now, things could be further restricted in the future.

The usage of influencers, key opinion leaders, celebrities and athletes to promote your brand may be possible. However, Ghogale pointed out that despite Indian Bollywood stars and athletes having tremendous fanbases among the rapidly growing conservative middle class, they are reticent to share any content of them consuming alcohol for fear of alienating their fans. There is scope to explore relationships with current and former Australian cricketers.

USING ON-PREMISE TO BUILD YOUR BRAND

In 2011, I worked on an exploratory project in four Indian cities to try and understand the wine features most important to those making wine list decision-making in restaurants (Cohen *et al*. 2018). The most important features in choosing what wines to list were well-known brand, taste, recommendation from the supplier and food matching. The remaining features tested were drastically less important. Whilst this study is dated and small in scope, it can serve as a roadmap for a larger-scale study now on what would currently motivate trade. This becomes even more pertinent when you factor the ban on alcohol advertising in India.

Wine Australia has developed tremendous expertise from its successful development of the China market in providing wine education and training. I believe this experience is useful in building a similar campaign to engage with the Indian hospitality sector. Getting these gatekeepers to list and promote Australian wine is not just important for growing our performance in out-of-home consumption, but also to help build mental availability for the Australian category when Indians have a purchase occasion in a retail setting.

WHERE TO FOCUS OUR EFFORTS

Biswas (2020) pointed out that the selling of alcohol has always been a challenge in India. Ghogale said, "India is a very complex market. Think of it much like the United States, multiple state-level laws that are vastly different from one another. The southern states have government-controlled monopolies very similar to Scandinavia and Canada. The North is basically a free for all. Liquor licences are hard to come by and typically require political influence." We should be focusing on building penetration in cities with the largest penetration of alcohol users such as Pune (the home of the Indian wine industry), Mumbai, Lucknow, Bhubaneshwar, Hyderabad, Delhi and Bangalore (Statista 2022). Since it will be challenging to reach potential buyers through advertising, we need to focus on utilising sales channels that give us the most access to potential buyers, but temper that with retailing environments where we can perhaps invest the marketing dollars we would use on advertising on in-store activation.

AUSTRALIA IS AT IS BEST WHEN IT WORKS TOGETHER

In our glory days trading with China, the floodgates were open for both outbound and inbound business. Our wine, tourism, education and immigration sectors all sensed the need to work together as there was a symbiotic benefit. A white paper was published in 2014 for The Australian Marketing Institute talking about the role of marketing and the opportunity that exists in blending food, wine, education and tourism in South Australia (Bowe and Cohen 2014). It is a pertinent time to revisit this and consider in a broader sense what opportunities exist for Australia to better engage the Indian market.

Due to the ban on alcohol advertising in India, there is an opportunity at a governmental and industry level to explore how we can make surrogate advertising work for the wine sector. For this to work, we need to have uniform conventions for 'Brand Australia' that help to communicate to the Indian market the value of imported goods and services from Australia as well as our nation's strengths in sport and as a destination for tourism and education. Consistent branding across these sectors' communications will give Australian wine the best chance of being noticed in a buying occasion. Working together will give us the best chance of growing Australian business interests in this fascinating market.

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Is the domestic market a good option for Australian wine businesses?

By Sandy Hathaway, Senior Analyst, Wine Australia

Australia as a wine market is the largest single destination for Australian wine, accounting for around 40 per cent of sales by volume.

With the challenges currently facing Australian wine exporters, many winemakers are shifting their focus to the domestic market. However, while the domestic market has a number of advantages, it has also experienced some changes that make it more challenging than it was three years ago.

AUSTRALIA LOSES ATTRACTIVENESS IN A GLOBAL CONTEXT OF DECLINING CONSUMPTION

In 2018, Wine Intelligence rated Australia as the world's eighth most attractive wine market in the world. However, in 2021 it slipped to 18th position. The most significant contributors to its decline were the relatively weak IMF forecast for short-term growth in GDP, indicating a slower-than-average economic recovery from COVID-19 (Australia ranked at 31 out of the 50 wine markets analysed) and a reduction in wine consumption, as well as other countries overtaking Australia by making significant gains in some areas[1].

According to Wine Intelligence's *Global Compass* market definitions, Australia has shifted from being an 'established' to a 'mature' market, and is characterised as having stable or declining volumes rather than showing any growth.

Total wine consumption in Australia has declined by an average of 1% per year from 2016 to 2020 and per capita consumption of wine has declined from 22.3 litres per year in 2016 to 20.2 litres per year in 2020 – a decrease of 9%[2].

Despite this decline, Australia remains the 10th largest wine-consuming[3] country in the world, with approximately 2% of global consumption. It has the second-highest per person wine consumption outside of Europe and is the highest-ranked English-speaking country in the world on this measure. Per capita wine consumption is more than double that of the United States of America.

With the challenges currently facing Australian wine exporters, many winemakers are shifting their focus to the domestic market. However, the domestic market has experienced changes that make it more challenging than it was three years ago. Photo: Wine Australia

Australia has retained its position because all but four of the top 20 global wine-consuming markets are 'established' or 'mature', according to Wine Intelligence's classification. This means that they are also generally declining or plateauing in terms of consumption, leaving very limited opportunities for growth among the world's main current wine-consuming nations.

SHAKE-UP IN SALES CHANNELS ON THE DOMESTIC MARKET

The Australian market is dominated by the off-trade, i.e. wine sold for consumption elsewhere (usually at home). It includes retail outlets, online/e-commerce purchases and direct-to-consumer (e.g. cellar door, wine club).

In 2020, the off-trade share increased in all wine-consuming countries[4], with on-premise sales (wine bars, restaurants, pubs and clubs) losing market share due to COVID-19 lockdowns and trade restrictions. Wine Australia modelling indicates that the off-trade in Australia made up 90% of domestic wine sales by volume in 2020-21, with in-store retail making up 66%, e-commerce 19% and direct-to-consumer (DTC) 13%.

Following the strong growth in 2020 at the expense of the on-premise, the latest figures[5] show that the retail off-trade declined by 7% in volume in 2021. The channel has not recovered to pre-pandemic levels, with sales volume in 2021 still 1% below the 2019 figure, consistent with the long-term overall decline in wine consumption.

E-commerce was the success story of the pandemic, with strong growth across all fast-moving consumer goods (FMCG) categories including alcohol. IWSR forecasts that e-commerce will continue to grow strongly, reaching a 5% share of total alcohol sales in Australia by 2023. However, wine is unlikely to see significant further volume gains as it is already well-established in this channel, while overall wine consumption volume is expected to

[1] *Global Compass* reports
[2] IWSR 2021
[3] All statistics refer to grape wine only
[4] IWSR 2020
[5] IRI MarketEdge January 2022

continue to decline. Any gains in e-commerce are likely to be at the expense of sales in other channels, particularly retail stores.

The on-premise has suffered significantly over the past two years, and IWSR forecasts that it will recover slowly and increase only very slightly by 2025, barely returning to 2019 volumes by then. This is a result of consumer behaviour changes, such as working and entertaining at home, persisting after the pandemic.

Wine's share of the on-premise sector is under pressure as overall wine consumption declines, and its traditionally strong association with food is undermined by younger drinkers with different taste preferences. These changes are long-term and not likely to be reversed by recovery from the pandemic.

The DTC sales channel provides a unique competitive advantage to local producers. It is a relatively high value channel although associated costs may also be higher than other channels.

For Australia's 1500 or so wineries producing fewer than 5000 cases, DTC accounts for well over half their annual sales revenue. DTC sales grew overall by 17% in value and 14% in volume in 2020-21, outperforming other channels and increasing profitability through an increased average value. Unfortunately, its overall share of the domestic market is only around 12% by volume, with many businesses competing for part of that share.

MORE COMPETITION FROM IMPORTED WINES

Imported wine accounted for 14% of the off-trade retail market by volume in 2021[6]. Its value share was 25%, reflecting the higher average value of imported wine. Overall, the average value of imported wine was $18.74 per 750ml compared with $9.59 for domestic wines.

Imported wines have been increasing in volume over the past five years, with growth accelerating during 2020 and 2021. As the overall market has been relatively flat, imported wine is taking market share.

CONSUMER PROFILES AND PREFERENCES ARE CHANGING

In Australia, unlike in many markets globally, the share of younger generations among regular wine drinkers has increased in the past three years. People aged between 25 and 44 (approximately Millennials) now make up 44% of regular wine drinkers, up from 35% in 2018. While people aged over 55 account for 29% compared with 36%[7].

According to Wine Intelligence, Millennials differ from their elders in that they are looking more for variety and experiences, and are less moved by low prices and/or reliable and familiar brands. This presents opportunities for new products, cellar door experiences and premiumisation, while the youngest Millennials are most likely to be interested in no/low alcohol products[8]. However, Millennials also drink less often than older cohorts, and there has been a dramatic shift in gender shares, with females now making up just 42% of regular wine drinkers compared with 50% in 2018.

The *Australian Wine Market Insights Report 2022* can be downloaded from www.wineaustralia.com

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[6] IRI MarketEdge

[7] *Australia Wine Landscapes* Wine Intelligence November 2021

[8] *Opportunities for low and no alcohol wine* Wine Intelligence March 2021

WVJ

Customer engagement in domestic wine tourism: *what is the role of motivations?*

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A recent study focusing on the Australian market has investigated what motivations drive tourists to visit wine regions.

INTRODUCTION & BACKGROUND

When marketing wine regions to wine tourists, it is imperative to understand what drives and motivates them to travel to these locations, but also what the response to their experiences are. These factors can then be managed in future wine tourism marketing to ensure long-term business (or regional) growth and success (Alant & Bruwer 2004, Vorobia *et al*. 2019).

We conducted a study to understand the aforementioned, with a key focus on the Australian domestic wine tourism industry, which has suffered many hardships after the loss of the Chinese wine market, and a lack of international travellers due to COVID-19, to name a few.

The study investigated what motivations drove wine tourists to visit a wine region; using *push* (intrinsic, psychological processes that compel a consumer to travel) and *pull* (the specific attributes of the region that were attractive) motivational theory. Motivations were further categorised as *wine* and *non-wine*, as we wanted to investigate the degree of broader hedonistic needs being fulfilled, but also the individual influence of tourists' wine involvement (WI) and wine knowledge (WK) (Charters & Ali-Knight 2002). Largely, we wanted to go beyond constructs of, for example, satisfaction, revisitation, brand image or word of mouth as the 'consumer response to experience', and instead applied the theory of customer engagement (CE), which accounts for the cognitive (think), affective (feel) and behavioural (act) manifestations of co-created consumer connections with regions. From this, we determined:

- the influence of WI and WK on motivations and CE
- the influence of motivations on CE and, most importantly
- the overall role of motivations, and if they mediated the relationship between WI/WK and CE.

This research was undertaken in 2021. Using Toluna as our professional panel provider, we distributed a survey to gather data from anonymous participants who were over 18, Australian residents/citizens AND had travelled to an Australian wine region in the prior six months.

A total of 232 survey responses were collected. After cleaning and checking the responses, we were then left with 220 complete and valid responses for analysis. Demographically, the sample size consisted of nearly equal men (49%) and women (51%), with most respondents (71%) originating from NSW (28%), VIC (26 %) and SA (17%). More than 40% of respondents had a university degree, with 71% of the sample earning $65,000 and above per annum (before tax). Regarding wine consumption, 68% of respondents drank wine at least once a week.

We then used this survey data to create a model using structural equation modelling (SEM); best for measuring the relationships between complex constructs. The following is what we discovered from our results.

WHAT MOTIVATES WINE TOURISTS TO VISIT A WINE REGION?

Our results found that the biggest set of motivators could be classified as *broader hedonic and experiential factors*. These were

IN **BRIEF**

- **It is important to understand what drives and motivates wine tourists when marketing wine regions to them.**
- **A recent Australian study investigated these drivers in the domestic market.**
- **Findings included that hedonic offerings such as festivals, recreational activities, local markets and monumental landmarks should continue to be considered, wine remains of great importance to many wine tourists so regions need to continue offering a diversity of wine experiences.**
- **Suggestions for advertising to domestic tourists have also been stimulated by the findings.**

factors such as the desire for new experiences (push), and regional attributes such as festivals/events, entertainment facilities, landmarks and monuments (pull), all of which were majority non-wine.

Almost equal to hedonic motivations (as commonly shared amongst participants) were *wine-specific motivations*, such as the desire to try and buy wine in a winery setting (push), and the wineries or cellar doors available in the region (pull).

The next motivational factors were *peace and relaxation*, which mostly comprised push motivations, related to taking a break, relaxing and spending one's free time.

Lastly, there was the motivation to *socialise*; this is self-explanatory and made for very little significance.

DOES WINE INVOLVEMENT AND WINE KNOWLEDGE AFFECT MOTIVATIONS AND ENGAGEMENT?

The results of the study showed that, yes, wine involvement (WI) and wine knowledge (WK) did have a positive and significant effect on motivations — but only a specific few.

It would intuitively make sense that WI only had a very significant influence on *wine-specific* motivations — as the consumer would already be highly involved with wine. However, we found interesting evidence that WK only had an effect on *broader hedonic and experiential* motivations. We can speculate that perhaps this is because those who are knowledgeable about wine are not necessarily interested or involved with wine, or because they already know about wine, they are more motivated to learn about and experience the region.

When investigating the relationship between WI, WK and customer engagement (CE), our findings indicated that WI and WK did not have any effect on engagement. This means that although a wine tourist may consider wine an important part of their life or personality, and may be knowledgeable, it does not necessarily mean they will develop a 'connection' with the wine region they visit. Motivations, however, do play a significant role here — which we will discuss later.

DO MOTIVATIONS AFFECT ENGAGEMENT?

When investigating whether motivations influenced CE, we found much evidence to confirm they do. Both wine-specific and broader hedonic motivations produced very positive and significant effects on CE, with peace and relaxation motivations generating somewhat significant effects on CE; not surprisingly, the minor 'socialisation' motivations had no effect at all — and we speculate this may be because, in hindsight, socialisation is an inherent element of most push/pull motivations.

Having determined why motivations may influence CE, and not purely WK/WI, we turn to the literature which allows us to infer that motivations lead to forms of engagement based on consumer psychology theories that motivations produce fantasies, imagery and expectations of perceived benefits. These are mostly affective and cognitive, and could potentially be subconsciously used as a reference for evaluating one's experience (see Alba & Williams 2013, Gnoth 1997, Goosens 2000). Further research would be required here, but this provides a compelling suggestion that perhaps engagement could be formed with reference to expectations derived from motivations — or perhaps the other way around — and engagement begins with motivations in the form of thoughts and feelings. This is also suggested in literature; the three main elements of CE (cognition, affect, behaviour) are also attributed to the 'key intervening responses' during hedonic (sensory, pleasurable or experiential) consumption (see Hirschman & Holbrook 1992).

WHAT IS THE ROLE OF MOTIVATIONS?

From our study and review of the literature, we found a few theoretical gaps to suggest that motivations acted as a mediating factor. This is also evidenced by the results discussed thus far in that WI/WK did not have a direct effect on engagement, but did have effects on motivations, and motivations affected CE. To help visualise this relationship, see Figure 1. This represents what we tested in our model. To determine mediation (i.e., that motivations intervene between WI/WK and CE), we had to look to *indirect effects*.

What we found, interestingly, is that motivations were a mediating factor. However, similar to the direct effects WI/WK had on CE, WI was only mediated by wine-specific motivations, and WK was only mediated by broader hedonic motivations. More simply, our findings suggest that those with high wine involvement would more likely form motivations centred around wine, which would increase their engagement when they visited wine regions; and those with high wine knowledge would more likely form motivations centred around broader hedonic elements, which would contribute to their level of engagement. This requires far more research, but from what we know this was the first study to test and confirm this.

CONCLUSION – WHY IS THIS IMPORTANT, AND HOW CAN IT BE USED IN MARKETING/MANAGING WINE REGIONS AND THE BUSINESSES THAT OPERATE WITHIN THEM?

From this study, we determine several suggestions for all stakeholders in wine regions — from cellar door managers to tourism bodies — to consider. First, our findings determine hedonic offerings to be a

Wine Involvement → Customer Engagement
(did not affect)

Wine Knowledge → Customer Engagement
(did not affect)

Wine Involvement and Wine Knowledge → Wine and Hedonic Motivations
(significantly affected)

All Motivations, except Socialisation → Customer Engagement
(significantly affected)

WI/WK → effects some Motivations → effects Customer Engagement
(proposed mediating effect)

Figure 1

key, top-of-mind offering in regions that should continue to be considered, for example, festivals, recreational activities, local markets and monumental landmarks. This is especially important as hedonic offerings can be easily enjoyed and accessed by anyone regardless of age or lifestyle or involvement/knowledge of wine. With that said, wine demonstrates great importance to many wine tourists, and regions need to continue offering a diversity of wine experiences such as tours and tastings. Perhaps including value-adding hedonic accoutrements within wine businesses could help attract a wider segment of tourists — for example, an added art gallery, a hiking trail through the vineyards, or theme-night parties.

When advertising to domestic tourists, our findings on motivations suggest that illustrating the 'world of wine', both hedonic and wine-related, should be presented. Allowing the consumer to see the unique and complex mix of attributes in the region could inspire motivations — especially those that involve co-creation, excitement, intrigue and learning, as these are key elements of customer engagement. Although the tangible are just as important as the intangible or subjective, we suggest promoting the emotions that would derive from visiting a wine region by including imagery relating to feelings of indulgence, relaxation, serenity and tranquillity.

Based on our findings, we also recommend that businesses and greater regions make use of implementing CE management initiatives. This involves the deliberate effort to involve consumers in co-creating and contributing to their experiences and the development of the businesses and/or region. While CE initiatives were not the direct focus of this research, the findings provide evidence that wine tourists can indeed develop CE with wine regions. As such, actions that involve the tourist to co-create their experience and provide feedback or suggestions are good examples of CE initiatives, although this would require further research and unique initiatives tailored to the business (Ng *et al*. 2020).

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Grape variety trends in South Australian wine regions, 2001 to 2021

By Kym Anderson[1] and German Puga, Wine Economics Research Centre, University of Adelaide, Adelaide, South Australia 5005

An article published in the Spring 2020 issue of the *Wine & Viticulture Journal* showed that the overall mix of winegrape varieties in Australia's vineyards had become less distinct from the rest of the world's winegrape trends. A recent analysis of what's been happening at the regional level, in particularly in South Australia — where almost half the nation's vineyards are located — has revealed that some of the state's regions have become more distinct from each other.

IN BRIEF

- **The share of bearing vines in South Australia planted to French varieties rose from 82% to 88% between 2001 and 2021.**
- **Although the percentage of vines in the state planted to red varieties has changed little this century, there have been substantial changes in the share of reds in individual regions, including the Adelaide Hills, Barossa Valley, McLaren Vale and the Coonawarra; the share of the favoured red varieties has also increased in the Barossa Valley and Coonawarra.**
- **Despite the exploration of 'alternative' or emerging varieties throughout the state, the concentration on fewer varieties also has changed little this century.**
- **Although the varietal mix across the state's wine regions has become more similar to the rest of the world's, regions within SA have differentiated themselves more by varietal mix over the past two decades compared with other regions.**

A recent *Wine & Viticulture Journal* article (Anderson and Nelgen 2020a) reported on trends this century in the mix of winegrape varieties in Australia's vineyards. It found they have become more concentrated on a few (especially red) French varieties, and the mix is now more like - or less distinct from - the rest of the world's winegrape trends. That article did not drill down to see what is happening at the regional level. Nor did it have any information on the revenue earnt per hectare from different varieties in the various regions. This article begins to fill that void by drawing on a newly-compiled 2001-2021 annual database of regional-by-varietal data for South Australia (Anderson and Puga 2021). That state accounts for almost half the national vineyard area and – more importantly for this article – it has more complete and more detailed data than other states. The latter is thanks to required annual reporting by SA growers to what was the Phylloxera and Grape Industry Board of South Australia, now Vinehealth Australia (now available at Wine Australia 2021 and earlier). In total this new SA database distinguishes 11 separate legally defined regions (geographical indications) plus three smaller residual areas, and more than 60 separate varieties that account for all but 3% of the state's total vine area (within that residual 3%, about 1% is accounted for by another 70 varieties grown by at least three growers, but their data are confidential; they are listed in Tables 3 and 6 of Anderson and Puga 2021). A subsequent *WVJ* article will report on non-South Australian regions once the Anderson and Puga (2021) database is expanded to include them, building from and updating the historic regional-by-varietal data reported in Anderson (2015).

SPAIN DOWN, FRANCE UP

As in the rest of Australia, in the second half of the 20th century vineyards in South Australia moved away from varieties suited to fortified wines. In the early 1960s, when South Australia produced three-quarters of the country's wine, the national share of bearing area planted to varieties originating from Spain was more than 40%, while the share of those of French origin was less than 20%. By the turn of the century those shares were less than 4% and more than 80%, respectively. The situation has not changed as rapidly this century, but that trend has continued: in South Australia the share of French varieties rose from 82% to 88% between 2001 and 2021. Meanwhile, Germany's share has been around 4%, as has Spain's, but Italian varieties continue to account for barely 1% of the state's winegrape area (Figure 1).

RED'S REVIVAL, EXCEPT IN THE HILLS

The share of red varieties in the national vineyard also changed a lot in the second half of the 20th century, from 35% in the early 1960s to 50% in the early 1970s, back to 35% in the late 1980s, and then 60% by 2000 (Anderson 2015). South Australia's share of red varieties has been a little higher, and has not changed much this century, averaging close to 70%. However, there have been substantial changes in that share for individual regions. In the Adelaide Hills, for example, the share of red varieties has fallen from three-fifths to two-fifths, while in the Barossa Valley and McLaren Vale it has risen from around 70% and 80%, respectively, to 90% in area terms (and to even higher shares of winegrape production volume and value). Even in Coonawarra where traditionally the area share of reds has been high, it has crept up from 86% to 92% over the past two

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decades (Figure 2). Both the Barossa Valley and Coonawarra also have raised the share of their favoured red variety between 2001-03 and 2019-21, from 43% to 64% for Syrah in the former and from 57% to 64% for Cabernet Sauvignon in the latter. These are clear signs of those regions moving toward their varietal comparative advantage. So, too, has the Clare Valley, whose share of Riesling in total bearing area has risen over that same period from 15% to 21%, when that variety's share for the state has fallen from 4.2% to 3.1%.

LESS DISTINCT FROM THE GLOBAL VARIETAL MIX

The concentration on fewer varieties also has changed little this century, notwithstanding the exploration of 'alternative' or emerging varieties. The top three (Syrah/Shiraz, Cabernet Sauvignon and Chardonnay) accounted for 65% of the state's bearing area in 2001, and by 2021 that was 72% - and among the reds Shiraz is increasing its lead over Cabernet Sauvignon (Figure 3). That has brought the state's varietal mix closer to that of the rest of the world's, which itself has become more concentrated on key French varieties and on reds (see Anderson and Nelgen 2021). The extent of South Australia's convergence on that changing global mix is measured by our varietal similarity index (VSI), which is like a correlation coefficient that ranges from zero to one: it indicates how close the varietal mix of one region is to another region or to the state or world average mix, based on varietal shares of total bearing area (see the formula in Anderson and Nelgen 2021). In 2001, that index for SA vis-à-vis the world mix was 0.47 (almost the same as Australia's 0.46), but by 2021 it was 0.65. And each of the state's wine regions has become much more similar to the world in its varietal mix, although least so for the Barossa Valley (Figure 4, page 77).

To drill down to get a clearer idea of the contribution of different varieties to that rising VSI, it is helpful to generate the varietal intensity index (VII), defined as a variety's share of the bearing area in South Australia relative to its share in the world. Shown in Table 1 (page 76) are the 30 varieties with the highest VIIs for the state in 2021. The VIIs of the top seven in that table have all declined substantially this century, indicating that their shares in the state's bearing area have grown less rapidly than in the rest of the world. This is particularly true of Syrah, Cabernet Sauvignon, Riesling and Chardonnay, whose combined share of the world's vine area grew from 11% to 17% between 2000 and 2016 (Anderson and Nelgen 2020b).

Also evident from Table 1 are the declining VIIs for varieties previously used for non-premium or fortified wines (Muscat of Alexandria, Ruby Cabernet, Sultaniye),

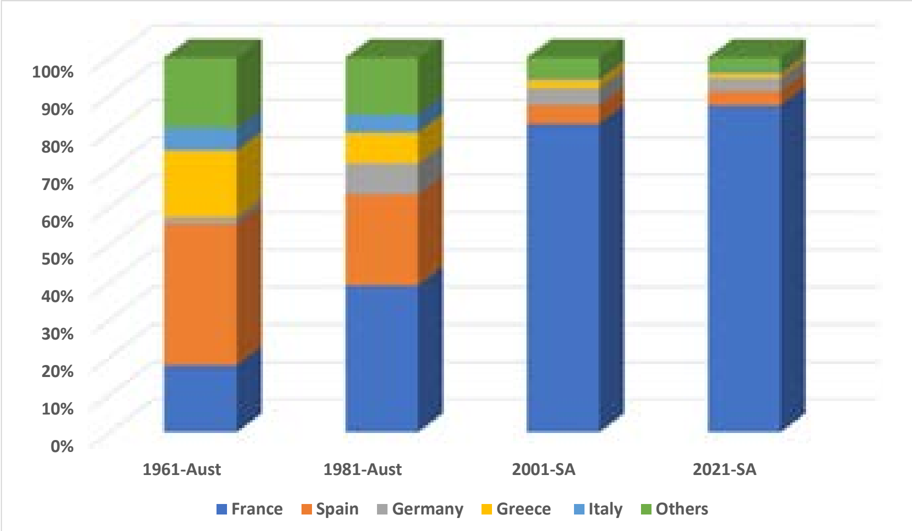

Figure 1. Shares of winegrape bearing area, by varietal country of origin, Australia 1961 and 1981, and South Australia 2001 and 2021 (%). Source: Anderson (2015) and Anderson and Puga (2021).

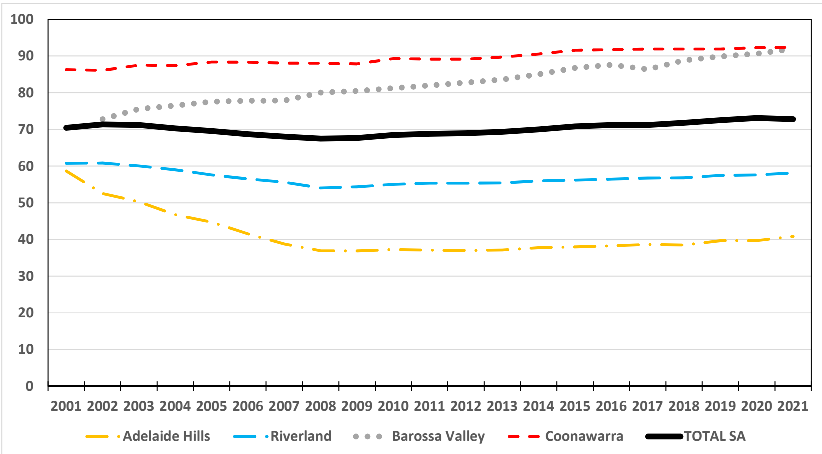

Figure 2. Shares of South Australian winegrape bearing area planted to red varieties, by region, 2001 to 2021 (%). Source: Anderson and Puga (2021).

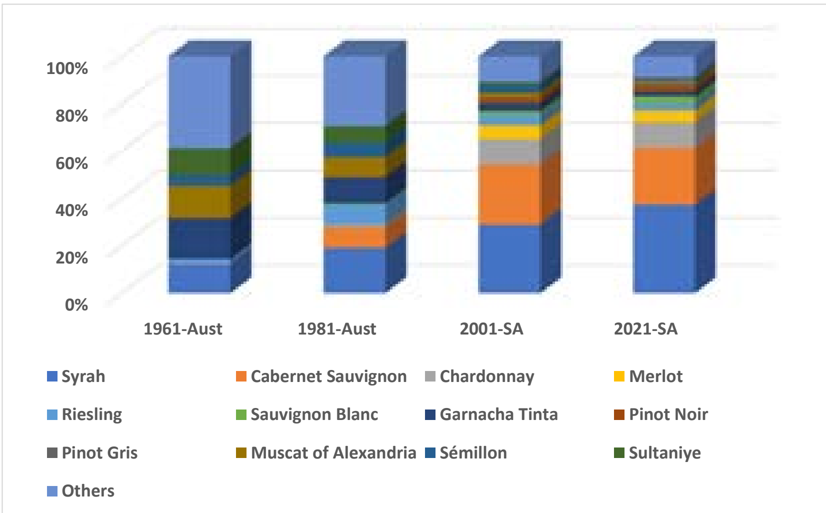

Figure 3. Shares of winegrape bearing area, by variety, Australia 1961 and 1981, and South Australia 2001 and 2021 (%). Source: Anderson (2015) and Anderson and Puga (2021)

and the rising (from zero) VIIs for emerging varieties such as Fiano, Lagrein and Pinot Gris. At the end of last century it was thought Viognier might be an emerging variety in SA, but its share of the state's vineyard peaked in 2010 and has since nearly halved while its share in the rest of the world has kept growing rapidly.

… BUT SA REGIONS ARE BECOMING MORE DISTINCT FROM EACH OTHER

The state average varietal shares hide a much greater degree of change at the regional level. For example, while the similarity index reveals that the varietal mix in each SA region has become more similar to the rest of the world's (although least so for the Barossa Valley and Adelaide Hills – see final column of Table 2), the varietal mix in the majority of SA regions has become *less* similar to the state average (see second to last column of Table 2). That is, regions within SA have differentiated themselves more over the past two decades from other regions in the state, not only in their share of reds but more broadly in terms of their overall varietal mix. The other columns of Table 2 reveal the extent to which various pairs of regions have become more or less similar in terms of their varietal mix. The majority have become less similar to other SA regions.

CHANGED RANKING OF REGIONS IN TERMS OF WINEGRAPE VALUE

The ranking of the state's wine regions in terms of area has not changed over the past two decades. The Riverland's share has dropped a little and that of the Barossa Valley has grown a little, but the ranking at the beginning is the same as at the end of that period (Figure 5(a), page 79).

With differing climates, weather variations and extent of irrigation used across the regions, their average yields per hectare differ considerably (Table 3, page 78). In particular, yields in the warm irrigated Riverland region have averaged more than three times those in the rest of the state (20.5 vs 6.6 tonnes/ha). Average prices over the past two decades have differed greatly across regions too (middle columns of Table 3), and not always inversely with yields. So, with the varietal mix also differing across regions, one might not expect the ranking of the state's regions to be the same in terms of winegrape crush value as that for bearing area. But, in fact, they were ranked not very differently in 2019-21 (which is the ordering criterion in Figure 5(b), page 79). The main differences between the beginning and end of this two-decade period are that Coonawarra and the Adelaide Hills are now ahead of Langhorne Creek, and the Clare Valley is behind Wrattonbully in the value chart as compared with the area chart (compare Figures 5(a) and 5(b)). What is more striking is that the regions have altered substantially in their value rankings over the past two decades. McLaren Vale has been overtaken by the Barossa Valley, and the Adelaide Hills is now ahead of Padthaway and the Clare Valley (Figure 5(b)).

… AND CHANGED REGIONAL RANKING OF AVERAGE PRICES

The regional average prices over the past two decades (column 8 of Table 3) conceal substantial changes over that period in the average winegrape price for each region, and the regions' within-state rankings by that criterion. The five highest-priced regions in 2019-21 have higher average prices at the end than the beginning of this two-decade period, led by the Barossa Valley, Eden Valley and McLaren Vale (column 6 of Table 3). The range of average regional prices has risen from $1110 in 2001-03 to $1720 in 2019-21, even though the state's average price is one-sixth lower in nominal terms in 2019-21 than in 2001-03.

Offsetting this, average yields per hectare have fallen in several of today's high-priced regions and have risen most in the low-

Table 1. Varietal intensity index of winegrape varieties in South Australia relative to the world, 2001, 2011 and 2021. Source: Anderson and Puga (2021).

	2001	2011	2021
Syrah	12.76	8.03	7.96
Verdelho	12.02	7.30	4.93
Petit Verdot	30.48	6.15	4.93
Cabernet Sauvignon	5.09	3.40	3.48
Riesling	4.40	3.52	2.51
Chardonnay	3.19	3.06	2.44
Sémillon	5.34	3.82	2.38
Lagrein	0.00	0.90	2.37
Fiano	0.00	0.00	2.01
Colombard	1.35	1.56	1.47
Muscat of Alexandria	3.28	2.37	1.46
Pinot Gris	0.16	1.24	1.38
Sultaniye	4.69	3.49	1.35
Ruby Cabernet	9.08	1.85	1.34
Viognier	4.05	2.76	1.09
Sauvignon Blanc	1.19	1.38	1.08
Pinot Noir	1.40	0.99	0.90
Durif	0.45	0.33	0.84
Merlot	1.20	0.94	0.83
Monastrell	0.55	0.54	0.80
Muscadelle	2.70	1.11	0.75
Gewürztraminer	0.76	0.81	0.73
Garnacha Tinta	0.69	0.59	0.65
Sagrantino	0.00	0.00	0.52
Savagnin Blanc	0.00	0.91	0.45
Côt	0.82	0.36	0.42
Roussanne	0.00	0.48	0.42
Arneis	0.00	0.00	0.35
Marsanne	0.20	0.80	0.29
Graciano	0.00	0.00	0.29

The varietal intensity index (VII) is defined as a variety's share of the bearing area in South Australia relative to its share in the global bearing area of winegrapes in years 2000, 2010 and 2016 (the most-recent year available), from Anderson and Nelgen (2020b). The 30 varieties with the state's highest VIIs in 2021 are shown here.

Table 2: Varietal similarity indexes between pairs of South Australian regions, and between them and the world,a 2001 and 2021

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Adelaide Hills	2001	1.00	0.65	0.70	0.65	0.56	0.69	0.83	0.71	0.85	0.76	0.66	0.77	0.50
	2021	1.00	0.31	0.33	0.27	0.44	0.41	0.51	0.34	0.54	0.61	0.37	0.50	0.55
2 Barossa Valley	2001		1.00	0.93	0.64	0.84	0.87	0.75	0.98	0.82	0.88	0.70	0.93	0.38
	2021		1.00	0.87	0.49	0.84	0.87	0.71	0.99	0.81	0.80	0.67	0.88	0.42
3 Clare Valley	2001			1.00	0.81	0.92	0.94	0.86	0.94	0.91	0.90	0.84	0.97	0.41
	2021			1.00	0.67	0.98	0.90	0.80	0.89	0.86	0.78	0.84	0.90	0.53
4 Coonawarra	2001				1.00	0.63	0.92	0.95	0.70	0.79	0.76	0.98	0.85	0.43
	2021				1.00	0.58	0.85	0.92	0.59	0.81	0.65	0.97	0.79	0.58
5 Eden Valley	2001					1.00	0.76	0.66	0.80	0.76	0.72	0.66	0.82	0.34
	2021					1.00	0.86	0.75	0.86	0.87	0.82	0.71	0.89	0.52
6 Langhorne Creek	2001						1.00	0.94	0.92	0.86	0.90	0.96	0.97	0.43
	2021						1.00	0.95	0.92	0.97	0.89	0.94	0.99	0.61
7 Other Limestone Coast	2001							1.00	0.82	0.90	0.86	0.95	0.93	0.47
	2021							1.00	0.78	0.94	0.85	098	0.94	0.70
8 McLaren Vale	2001								1.00	0.87	0.92	0.77	0.96	0.41
	2021								1.00	0.86	0.84	0.75	0.92	0.48
9 Padthaway	2001									1.00	0.90	0.78	0.93	0.46
	2021									1.00	0.95	0.91	0.98	0.64
10 Riverland	2001										1.00	0.80	0.96	0.48
	2021										1.00	0.78	0.94	0.65
11 Wrattonbully	2001											1.00	0.89	0.44
	2021											1.00	0.91	0.64
12 All SA	2001												1.00	0.47
	2021												1.00	0.65
13 WORLD	2001													1.00
	2021													1.00

World's varietal mix refers to 2000 and 2016, which are the nearest years available, as estimated by Anderson and Nelgen (2020a). Source: Anderson and Puga (2021).

priced Riverland (column 3 of Table 3). So, what does all this (including changes in each region's mix of varieties) translate to in terms of gross revenue per hectare?

GROSS REVENUE PER HECTARE

Winegrape gross revenue per hectare data are summarised by region and variety in the final columns of Table 3, with the regions listed alphabetically and the varieties ranked in terms of the state's bearing area in 2019-21 (when those 14 varieties accounted for 96% of the state's vine area). Several things are worth noting from some of those numbers and their depiction in Figure 6 (page 79).

First, the beginning and end of the two-decade period were high-priced compared with the vintages in between (Figure 6(a)).

Second, the ranking of regions in terms of average price is different from that in terms of gross revenue per hectare over the 21 vintages since 2001 (Figure 6(b)). Indeed, the latter indicator varies little across regions compared with the wide variation in average prices. In particular, the low-priced hot irrigated Riverland region returned a similar 21-year average gross revenue per hectare as the high-priced Adelaide Hills and McLaren Vale regions. Notice also that Eden Valley and Clare Valley – whose shares of Riesling in total bearing area are currently more than seven times the state average – have much lower revenue per hectare than any other SA region.

Third, the state's 2019-21 average price and average gross revenue per hectare are both nearly one-fifth below that of 2001-03, while the state's average yield per hectare is almost the same in 2019-21 as in 2001-03. The yield change varies a lot across regions, though: it rose by slightly more than one-quarter in the Riverland but fell in the four highest-priced regions (Table 3).

Fourth, an additional contributor to the above changes is the combined set of changes in varietal mixes across regions, since there are huge differences in the average prices paid for each variety and the differences varied a lot across those 21 vintages (lower half of Table 3).

Even when considering just the state averages of varietal prices for the top 14 varieties (in terms of bearing area), Table 3 shows that their three-year averages have ranged from less than \$300 to more than \$1200 per tonne. That table also shows how much those prices have changed this

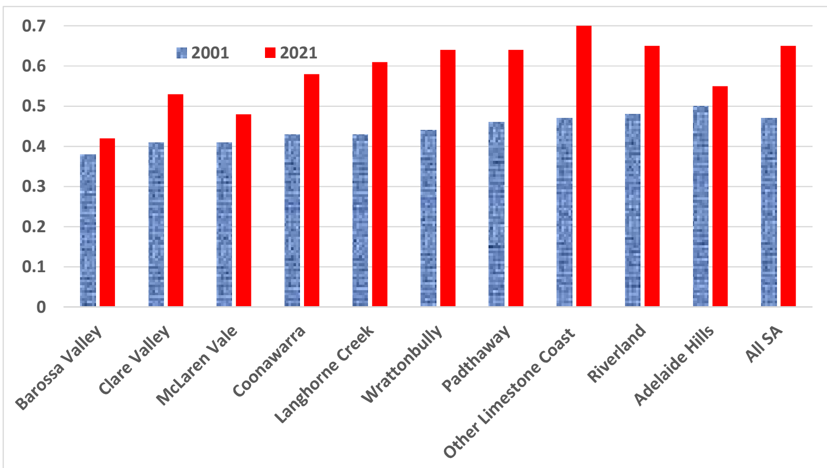

Figure 4. Index of varietal similarity between South Australian wine regions' winegrape varietal mix and that of the world, 2001 and 2021. Source: Anderson and Puga (2021).

Table 3. Average winegrape price per tonne and per hectare yield and gross revenue, by region and by variety, South Australia, 2001-21.

	yield/ha (tonnes)				price/tonne (AUD)				value/ha (AUD)			
	2001-03	2019-21	2019-21/ 2001-03	2001-21	2001-03	2019-21	2019-21/ 2001-03	2001-21	2001-03	2019-21	2019-21/ 2001-03	2001-21
Adelaide Hills	5.41	5.14	1.0	**6.46**	1696	1625	1.0	**1439**	8991	8541	1.0	**9348**
Adelaide Plains	14.24	6.48	0.5	**8.52**	1159	1065	0.9	**879**	16746	7106	0.4	**7904**
Barossa Valley	5.78	3.73	0.6	**5.12**	1412	2224	1.6	**1507**	8799	8429	1.0	**7770**
Clare Valley	4.91	3.43	0.7	**4.27**	1454	1551	1.1	**1234**	7547	5409	0.7	**5407**
Coonawarra	6.12	6.49	1.1	**5.94**	1759	1491	0.8	**1298**	10706	9408	0.9	**7661**
Eden Valley	4.59	2.59	0.6	**4.52**	1607	2060	1.3	**1572**	7906	5479	0.7	**6737**
Langhorne Creek	9.54	6.61	0.7	**8.34**	1397	1049	0.8	**993**	13408	6861	0.5	**8752**
McLaren Vale	8.49	4.43	0.5	**6.22**	1682	1908	1.1	**1494**	14608	8466	0.6	**9280**
Padthaway	8.27	8.01	1.0	**8.69**	1509	1046	0.7	**963**	13153	8298	0.6	**8195**
Riverland		19.32	24.37	**1.3**	649	505	0.8	**429**	12775	12347	1.0	**8877**
Wrattonbully	7.77	8.58	1.1	**7.84**	1561	1244	0.8	**1163**	11993	10153	0.8	**9088**
SA (all)		**10.46**	**10.34**	**0.99**	**1035**	**853**	**0.82**	**774**	**10943**	**8996**	**0.82**	**8074**
Syrah/Shiraz	10.01	8.61	0.9	**8.94**	1248	1144	0.9	**982**	12238	9842	0.8	**8862**
Cabernet Sauvignon	9.21	8.21	0.9	**8.35**	1215	1030	0.8	**888**	11426	8405	0.7	**7472**
Chardonnay	13.72	17.16	1.3	**14.95**	1019	494	0.5	**580**	13909	8563	0.6	**8602**
Merlot	9.87	12.32	1.2	**11.02**	1057	738	0.7	**704**	10359	9027	0.9	**7719**
Riesling	6.37	5.69	0.9	**6.87**	1016	1184	1.2	**963**	6252	5824	0.9	**6445**
Sauvignon Blanc	7.71	14.31	1.9	**11.44**	1040	709	0.7	**871**	7938	10370	1.3	**9730**
Garnacha Tinta/Grenache	9.80	6.02	0.6	**7.76**	865	1265	1.5	**890**	8351	7653	0.9	**6765**
Pinot Noir	8.59	10.43	1.2	**10.63**	1135	1024	0.9	**924**	8788	11000	1.3	**9816**
Sémillon	13.39	13.39	1.0	**13.95**	704	389	0.6	**494**	9350	4992	0.5	**6824**
Muscat of Alexandria	21.42	30.22	1.4	**22.76**	339	295	0.9	**325**	8853	8890	1.0	**7362**
Colombard	27.72	34.68	1.3	**31.58**	388	293	0.8	**285**	10744	10120	0.9	**8917**
Petit Verdot	12.23	22.1	1.8	**17.27**	724	543	0.8	**463**	8518	13079	1.5	**8070**
Pinot Gris	3.45	13.21	3.8	**8.54**	1635	864	0.5	**1227**	5834	11775	2.0	**9992**
Monastrell/ Mataro	14.64	6.73	0.5	**8.70**	621	1126	1.8	**780**	8908	7738	0.9	**6431**

Source: Anderson and Puga (2021).

century: the average prices of the lower-priced varieties have declined in nominal terms while prices of today's higher-priced ones have tended to rise, led by Monastrell, Garnacha and Riesling. However, Monastrell and Garnacha yields per hectare are much lower now than two decades ago, such that their 21-year average gross revenues per hectare, and that of Riesling, are among the lowest of those shown in the final column of Table 3.

CONCLUSION

This newly-compiled database reveals much about changes in the varietal mix in South Australia's vineyard regions which, together with changes in varietal prices and their yields per hectare, has altered the rankings of the state's regions in terms of gross revenue per hectare of vines. The drift toward a few popular French varieties has continued this century, as has the increasing concentration on red varieties in the state. But those trends are even stronger in the rest of the world, which means the global distinctiveness of the state's varietal mix has declined. Yet within the state the various wine regions have become more distinct from each other, the most extreme examples being the Barossa Valley and the Adelaide Hills. As well, the rankings of regions in terms of average winegrape prices and gross revenue per hectare of vines have altered considerably. The move toward emerging varieties has so far played only a small part in these developments: there are another 70-plus varieties not reported separately in the database because they are grown by less than a handful of growers (they currently account for less than 2% of the state's vine bearing area) and, so, their data are confidential.

Helpful though the above summaries of trends are, many questions remain to be answered by further analysis. For example, why is there still a two-fold divergence in gross revenue per hectare between the highest and the lowest by region, and by variety? It is especially surprising that the Riverland has the highest gross revenue per hectare when it may also have the lowest costs of production per hectare – at least in years when the price of irrigation water is low? How are the decreases in gross revenue per hectare to be reconciled (in terms of changes in yields per hectare and in the mix of varieties) with rising vineyard purchase prices in some regions?

Repeating this analysis for other states is a work in progress. Unfortunately, the bearing area data by variety and region are not available for those other states for years after

2015 (which is when the Australian Bureau of Statistics ceased surveying the industry), so it will involve first estimating those areas.

A strong case has been made recently by former Wine Australia deputy chair Brian Croser for Australia's wine industry levy system to be simplified to a single levy based on the value of each grower's winegrape crush (Croser 2021). If or when such a reform is implemented, the industry would be well served to include in that single levy the small amount that would be needed to broaden Vinehealth Australia's charge, currently on just SA growers, to growers in other states to fund the annual collection of vine area data by variety in every wine region in the country, so that a complete picture of the varietal composition of the nation's vineyards can be obtained and analysed going forward.

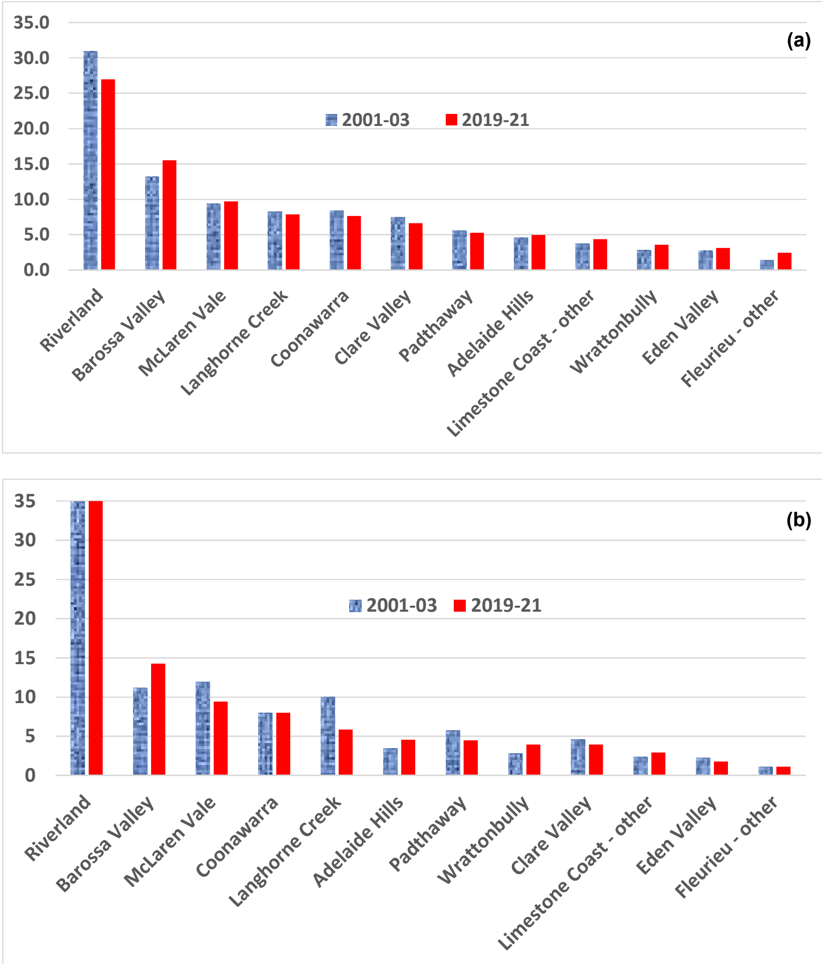

Figure 5. Regional shares of South Australian winegrape area and value, 2001-03 and 2019-21 (%).Source: Anderson and Puga (2021).
(a) Vineyard bearing area shares (%)
(b) Winegrape gross revenue shares (%)

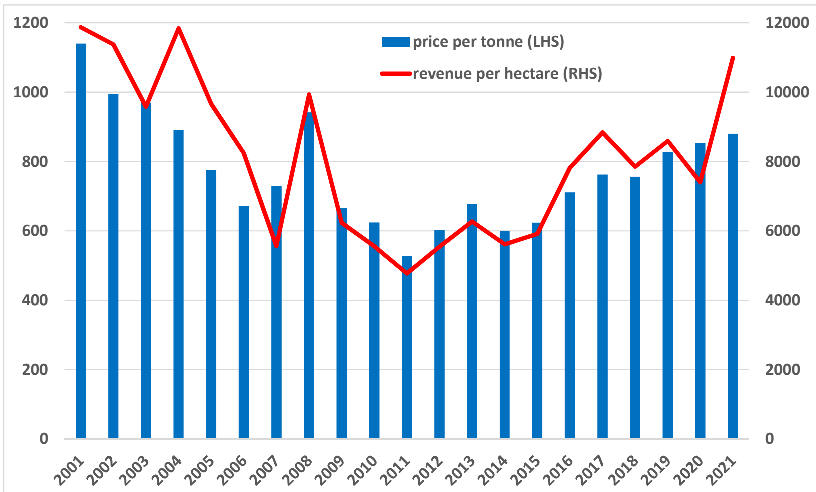

Figure 6. Average winegrape gross revenue per hectare and price per tonne, South Australia, 2001 to 2021 (nominal AUD). Source: Anderson and Puga (2021).

ACKNOWLEDGEMENTS

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WVJ

Getting a grip on Gruner Veltliner

Twenty Gruner Veltliners — 17 from Australia and three from New Zealand — were blind tasted for this issue of the Journal (see results page 83). With the benefits of vine age starting to reward early adopters of the variety in Australia, the producers behind the best three wines share how they've crafted their top drops.

PETER SATURNO
CHIEF EXECUTIVE/WINEMAKE
LONGVIEW
ADELAIDE HILLS, SOUTH AUSTRALIA

LONGVIEW 2021 MACCLESFIELD GRUNER VELTLINER
(RRP$30.00/BOTTLE)

Longview chief executive and winemaker Peter Saturno.

BACKGROUND

Whilst working in New York, I fell in love with Austrian wine, in particular Gruner Veltliner. I was enquiring about vine material when I heard Hahndorf Hill was bringing in new clones direct from Austria. After some positive conversations with Marc and Larry from Hahndorf Hill, we were able to obtain some material and became one of the first vineyards in the Adelaide Hills with plantings in the ground. We now have two hectares of 12-year-old Gruner comprising more than three different clones and the variety is now thriving as the vines gain maturity.

VITICULTURE

All the fruit for our Macclesfield Gruner Veltliner is estate grown from a single two-hectare block. The block is steep and faces south. The soil in the block is ironstone over clay loam. Three different Austrian clones — HHW 2, HHW 3 and Iby — are planted which are all on own roots. Half the vines in the block are 12 years old, 30% are 11 years old and 20% are 10 years old.

The block is approximately 300 metres above sea level. The steep slope of the block means frost isn't an issue due to good air drainage.

Vine rows are 2.4m apart while vines are 1.2m apart. The entire block is trellised to a VSP training system with cane pruning, first by machine and then by hand, carried out.

Careful shoot thinning and bunch thinning occurs every year. The block is irrigated in short bursts in summer with water sourced from our dam. In 2022 the block was grown organically as disease pressure was low and Gruner has a good ability to stay clean. Soil tilling helped ameliorate compaction and removed the use of herbicides.

Gruner is hard to taste in the field but can show great rotundone (pepper) characters in cool years. It can drop acidity easily if left to hang out although acid retention is much better now with vine maturity.

WINEMAKING

In 2021 the Gruner was hand-harvested based on flavour and acid retention, then crushed, destemmed and must-chilled to 3°C before gentle pressing. Only free run juice was used and the ferment was kept at sub 10°C, with some lees returned to the clarified juice to accentuate the mid-palate richness of the variety. It was then fermented to dryness and bottled immediately to preserve freshness.

MARKETING

Since the first vintage in 2013, we have tried to maintain consistency in style to avoid confusing consumers. We come together as a region for the Gruner Growers Group and discuss style and how to educate new consumers to the variety. This has been beneficial as the quality from the whole region has been elevated and we have had many great wines and vintages over the past decade. The Adelaide Hills now has the largest planting of Gruner Veltliner outside of Austria and the wine quality is world class.

BACKGROUND

In 2013 we were looking at an alternative variety as an experiment and to dip our toe into something a bit different for the domestic on-premise sector. Following discussions with our winemaker and viticultural manager, we identified Gruner Veltliner as a variety that would do very well in the Eden Valley. The variety responds well to large diurnal temperature variations which is typical of the Eden Valley.

Material was sourced from the Adelaide Hills Vine Improvement Society in 2013.

VITICULTURE

The fruit for our Gruner Veltliner is estate grown on a single block at 391 metres above sea level. The clone planted is HHWA 1-2 which was grafted in 2014 onto Teleki 5C rootstock. The row width is 2.75m and the vines are spaced 1.8m apart.

The rows are planted in a north-south orientation next to our Riesling block. They are trellised to a VSP to maximise airflow and sunlight into the canopy as well as shading of the fruit.

The soils in which the Gruner is planted are shallow, acidic, sandy loam over fractured schist rock substrate.

The minimum temperature experienced at the site is anywhere from 0°C (occasionally below) to up to 40°C degrees or more in the peak of summer during the day.

The 2020 vintage was extremely challenging — a continuation of the drought, frequent frosts, followed by winds that affected flowering and fruit set across the vineyard. The Gruner Veltliner fared better than other varieties and thankfully the ripening period was unusually mild. Part of the block is in a frost-prone location but is less susceptible than other areas of the property.

As part of our canopy management, shoot and bunch thinning is carried out to ensure vine balance.

The vines are irrigated via drippers with water from a surface dam. Soil moisture monitoring equipment is used to manage irrigation requirements throughout the season.

A permanent grass sward of multi mix species is established in the midrows. Compost is made on site and applied undervine with straw mulch applied over the top to conserve moisture, build soil health and enhance resilience to weather extremities.

Mechanical pre-pruning is followed by detailed hand spur pruning to 24 buds per vine. No synthetic fertilisers are applied and all nutrition is biologically based with the brewing of microbial compost teas and extracts to enhance vine and soil health.

The average yield over the last five years is 9.2 tonnes per hectare.

The main qualities looked for in the grapes at harvest is colour and flavour. We're looking for more golden fruit and consistency across the block, as well as tropical fruit notes with balanced natural acidity.

WINEMAKING

The fruit is machine picked at cool early morning temperatures and delivered to the winery. We gently bag press and use only the free run as we really want to allow the fruit to shine. A cultured yeast is introduced and there is no oak influence. Minimal intervention is the goal.

Once the wine has completed fermentation and is stable, we endeavour to bottle at the earliest possible time to retain freshness. The release date is ideally around 4-6 months from bottling once it has had time to settle down.

GRAEME THREDGOLD
GENERAL MANAGER
EDEN HALL
EDEN VALLEY, SOUTH AUSTRALIA

EDEN HALL 202 GRUNER VELTLINER
(RRP$30.00/BOTTLE)

From left, Graeme Thredgold, general manager, Dan Falkenberg, vititiculturist, and Phil Lehmann, Winemaker, from Eden Hall wines.

The variety ages very well and even though our first vintage was only in 2015, the results experienced to date from ageing are very impressive. We are excited to see where this journey takes us.

MARKETING

The wine fits into our split label premium offering — single vineyard, single block wine. The wine is offered to both on-premise and off-premise accounts via our Australian distribution network. Gruner Veltliner is, relatively, still in its infancy in Australia in terms of awareness and the on-premise sector is driving trial which we view as critical for its growth.

Demand has increased significantly and we have doubled our plantings in 2022. We see a bright future for the variety and we will be looking to increase volumes domestically and are considering potential export sales from 2023 onwards.

BACKGROUND

Wines by Geoff Hardy was one of the first producers in Australia to plant Gruner and we

SHANE HARRIS
SENIOR WINEMAKER
WINES BY GEOFF HARDY
ADELAIDE HILLS, SOUTH AUSTRALIA

WINE: K1 BY GEOFF HARDY 2021 GRUNER VELTLINER
(RRP$25.00/BOTTLE)

were the third to release a wine onto the Australian market after Lark Hill from Canberra and Hahndorf Hill in Hahndorf. Gruner vines were first planted in our K1 vineyard — named for being the first commercial planting of vines in the Kuitpo region — in 2008.

VITICULTURE

The vineyard is located at Kuitpo in the southern Adelaide Hills.

The Gruner Veltliner vines were planted in 2008 on rootstocks. We have a mixture of the clone that was already in Australia (Tasmania) and some of the newer clones that Larry and Marc from Hahndorf Hill imported — approximately half of each.

The vines are trellised to a single cordon. Dam water is available for irrigation if required but in 2021 only two irrigations were required mid-season. Kuitpo receives good natural rainfall.

A permanent grass cover is cultivated in the midrows.

The vines are hand spur pruned.

Gruner is a fairly resilient variety and has very few issues in the vineyard.

We normally average 2.5-3 tonnes per acre. Overcropping when vines are young needs to be watched but now the vines are maturing they are fairly good at self-regulating to the season.

To determine harvest timing we look for flavour changes; the variety develops flavour quite late in the ripening process so you need to taste frequently. There are also physiological changes in colour that can give visual indication of change.

WINEMAKING

We make two wines each year off the K1 estate vineyard — K1 and Hand Crafted. We make several parcels during vintage to give blending options and ensure the wines remain distinct in their own right and show the versatility of the variety in expressing a single site in various ways.

The fruit is machine picked in the cool of night then taken to the winery for destemming, pressing, settling and inoculation. We do several picks during the course of the vintage. Early picks are settled more while I tend to leave more juice solids in the later picks. Free run and pressings remain separate during processing and different yeasts are used allowing more pure fruit expression in early picks and building texture and fruit weight in later picks and pressings.

Old Chardonnay oak is also used for a portion each year which can fluctuate between 10-50% of the final blend depending on the vintage. Partial malo can also be used on barrel portions in higher acid years.

The wines are mormally bottled in late June/early July each year. Gruner tends to suffer from bottleshock more than any other variety we work with. Even within the winery care must be taken to carry out each stage of production as gently as possible.

As the vines have matured we are finding they are giving more fruit weight, intensity and consistency each year to a point where for the last three years I would say we are now seeing the full potential of this variety in the Adelaide Hills.

We start each vintage one year wiser, so nothing is ever set in stone. We try to remain open minded and experiment wherever possible. This year I have been dabbling with some skin contact ferments which have given interesting results both aromatically and with regard to texture so we will see where these experiments land. WVJ

Senior winemaker for Wines by Geoff Hardy, Shane Harris.

Gruner Veltliner – the Austrian that doesn't play well with other children but is a darling with food

The Wine & Viticulture Journal's latest tasting put Gruner Veltliners from Australia and New Zealand under the spotlight for the first time.

The panel for our Gruner Veltliner tasting were (from left) Anita Goode, owner and winemaker for Wangolina in Mount Benson; Peter Saturno, chief executive and winemaker for Longview in the Adelaide Hills; and Shane Harris, senior winemaker for Wines by Geoff Hardy, also based in the Adelaide Hills.

Australia crushed a record amount of the Austrian variety Gruner Veltliner in 2021 — 453 tonnes, a jump of nearly 50% on the intakes during the previous three years, according to the most recently available vintage figures from Wine Australia. Conversely, the Gruner Veltliner crush in New Zealand dipped 25% in 2021 to 275 tonnes, numbers released by New Zealand Winegrowers show. Then again, the overall production of winegrapes in the country fell 19% that year. Between 2018 and 2020 the volume of Gruner Veltliner processed was in the 300-tonne range.

While it only ranked 18th in the list of the Australia's most crushed white varieties in 2021, 10th in New Zealand (down from 7th spot in the previous two years), the number of producers adding it to their repertoire has been steadily rising in line with the ongoing interest in alternative varieties. In Australia, 49 of the wine producers listed in the *2022 The Australian and New Zealand Wine Industry Directory*, published by Winetitles Media, said they processed Gruner Veltliner compared with 13 in 2015.

The first Gruner Veltliner produced in Australia was by Lark Hill in Canberra in 2009. Hahndorf Hill followed with its debut release from the Adelaide Hills the next year. Hahndorf Hill's owners Larry Jacobs and Marc Dobson have since become ambassadors for the variety which has resulted in its popularity growing throughout the Adelaide Hills. In 2009, together with the Adelaide Hills Vine Improvement association, Hahndorf Hill initiated the Gruner Veltliner Project whereby its clonal material was made available to other growers in the region. The project also resulted in the establishment of the Adelaide Hills Gruner Growers Group (GGG) which meets regularly to swap information and taste their most recent vintages.

Not surprisingly, Gruner Veltliners from the Adelaide Hills made up the majority of entries in the *Wine & Viticulture Journal*'s recent blind tasting. Among the wineries in the Adelaide Hills producing Gruner are Wines by Geoff Hardy and Longview, which not only submitted entries to our tasting but their winemakers in Shane Harris and Peter Saturno, respectively, sat on the tasting panel. They were joined by Anita Goode, owner and winemaker for Wangolina in Mount Benson, who also had an entry in the blind tasting.

At the conclusion of the tasting Shane Harris commented that all the entries in the tasting were "good, clean, well-made wines" with no faults. He said it was apparent that producers were trialling various production techniques with respect to picking times and in the winery.

"There's room to work the variety to different styles — it's good that people are experimenting with it. It's hard to do experiments when you've got small batches of fruit. In the Hills, one of our biggest advantages is we do annual tastings where everyone brings their current vintage so you get the learnings of 20-30 wines every year, you're not just looking at your own," Harris said.

"Gruner is a young variety in Australia — we're still learning each year how to handle it," he continued. Harris said as the nation's bearing Gruner vines aged, less manipulation of the fruit in the winery was needed to achieve good palate weight. "Now the fruit has [palate weight] inherently we can be a little bit more hands-off and let the vines speak for themselves as they mature."

GREAT VARIETAL SPECIFICITY

Peter Saturno said the wines in the tasting had "great varietal specificity".

"We're seeing Gruner for Gruner not Gruner that looks like Chardonnay or something else," Anita Goode agreed. "The notes coming through are varietal notes."

"There were some delicious drinking wines. Gruner is in a very exciting place moving forward, especially with vine age improving," Saturno added.

The panellists agreed that the varietal characteristics primarily associated with Gruner Veltliner were root vegetables such as radishes, parsnips and celeriac. Harris noted that in Austria, primary fruit characters were actively discouraged in the higher quality Gruner styles.

"They will actually pull anything back that has primary fruit character. When Gruner comes into the winery it's very oxidatively handled .There is no CO_2 used. They actively work against primary fruit right from the get go of receiving it. There are fruity styles within Austria but they tend to be cheaper. A vegetal, savoury line is regarded as a very positive thing," Harris explained.

Saturno declared Gruner to be "the most versatile food wine in the world".

"The savoury edge in these wines makes them absolutely fantastic with food," Harris agreed. "They go with such a broad spectrum of food and they highlight meals. If you give it some savoury, earthy flavour to work with it absolutely sings. Rare roast beef, pork knuckle, Wiener schnitzel, even apple strudel — it absolutely hums. It has a great amplifying effect when it's working with other flavours. Not all wines do that."

Saturno said Gruner was "a difficult variety to taste in the field". "You have to look at your numbers and back your instincts in a way," he said. Harris said vineyard sampling should be carried out often enough to pick up on changes in fruit flavours. "That doesn't mean looking at the vineyard once a week, it needs to be a couple of times a week," Harris said. "Gruner has late flavour development – it doesn't look like much until it's ready to pick."

Saturno said Gruner handled heat well and had very good resistance to disease, particularly mould. "So, it's a gem for cooler climates. Our Gruner block was almost managed organically this year. It's just one of those varieties that's hardy like that."

"It loves to throw a crop," Goode added, prompting Harris to note that over-cropping would result in a loss of fruit weight and definition of characters. But he'd observed that Gruner was good at self-regulating its crops as vines aged.

"What we're seeing now with more mature vineyards is it self-regulates. In a year where it can hold more crop, it does crop up a little bit. But in years where we've had less water you do notice the vines do react fairly well. It's probably one of the best varieties that we have at K1 for self-regulation. Very rarely do we have to go through and crop thin now that the vines have left their first five years of being a recalcitrant teenager behind them."

The viticulture and oenology students from the University of Adelaide who tasted a selection of the Gruner Veltliners from our recent tasting, pictured with Sue Bastian (front row, second from left), Associate Professor in Oenology and Sensory Studies at the School of Agriculture Food and Wine.

BLENDING WITH GRUNER

Both Saturno and Harris commented that any blending with Gruner tended to stand out.

"We have up to 36 varieties that we play with from the K1 vineyard," Harris said. "In the early days, particularly when we were dealing with young vines and they were looking a bit thin, I tried blending Gruner with everything known to man. But every single release of our Gruner has been 100% Gruner because it doesn't play nicely with other children. I've got down to half a percent with Riesling and Gewürztraminer and it just kicks up a stink every single time. I've tried free run Chardonnay, mid pressings Chardonnay, Chardonnay sparkling base, Arneis, Fiano. I'm talking no more than 5%. It has never played nicely with other children at all. Not once have I ever added another variety to it."

Harris added Gruner tended to "sulk more than any other variety" in response to its environment during the winemaking process.

"If I decide to make any acid additions to Gruner, for example, I'll do so before moving it because even the cavitation of a pump can cause it to sulk the other side. I find Pinot and Chardonnay quite frustrating — you do some work and you look at them shortly after and they're all arms and legs and you need to give them time. Gruner is even worse."

All three tasters commented that Gruner's behaviour once in bottle could be erratic.

"In our first couple of vintages, I'd look at the Gruner a couple of weeks later [after bottling] and think, 'what have I done?' or 'what happened on the bottling line'?," recalled Harris. "Then six weeks later I'd go, 'I don't know what I was worried about'. You need to have faith in what you see in the vineyard and winery and then send it off to bottle. It's a delicate variety even though it doesn't appear delicate in the glass."

Harris said in the last couple of vintages he'd reintroduced older oak in making his Gruners to use as a blending component having completely removed the influence of oak in the preceding two or so years. He also played with a bit of skin contact in the most recent vintage. He said the next aspect in line for experimentation was ferment temperatures.

"Warmer ferments scalp some fruit but those warming, creamy notes that come from that I think are worth playing with a little bit to see how it changes style."

Goode said she'd always used a component of Gruner that had been fermented in ceramic vessels.

"About a third is made in ceramic. That adds that front forward palate weight that you don't see from oak," she said.

The panellists agreed the top wines of the tasting were: K1 by Geoff Hardy 2021 Gruner Veltliner, Longview 2021 Macclesfiled Gruner Vetliner and Eden Hall 2020 Gruner Veltliner.

Following the tasting, a selection of the wines were put before a group of viticulture and oenology students from the University of Adelaide about a month later. Their collective comments on those wines are noted separately in the following tasting notes.

K1 BY GEOFF HARDY 2021 GRUNER VELTLINER
Adelaide Hills, South Australia
13.0%v/v
RRP$25.00/bottle

Best of tasting: Pale lemon yellow with a slight green tint. Great savoury line on the nose which has good varietal definition – notes of celery, root vegetables (radish, turnip) and grapefruit. Pepper, celery and apple characters on the palate which has great fruit weight and intensity. Nice mouthfeel with a good acid line although acid is a touch puckering and sour. “Extremely varietal,” noted one taster.

Students: Fresh, savoury nose of citrus, green apples, stonefruit, passionfruit, root vegetables (turnip), green vegetables, celery, lime and lemon rind, white flowers and a slight green herbal note. Characters of lemon, lime and stonefruits on the palate. Crisp, mouthwatering acid. Good balance of fruit flavour and acidity.

LONGVIEW 2021 MACCLESFIELD GRUNDER VELTLINER
Adelaide Hills, South Australia
12.5%v/v
RRP$30.00/bottle

Best of tasting: Bright colour of pale to mid straw with a yellow rim. Ripe, lifted, fruit-driven and varietal nose featuring notes of quince, mandarin, lemon/lime, custard apple, turnip, grapefruit and tinned pineapple. Nose is bright, fresh and clean and has a great lift. Bright, fresh and fruit-driven palate which has some sweetness. Nice acid balance. Spicy finish. “A very drinkable, well made, modern style – a good ambassador for the variety,” noted one taster, adding that it is “not too savoury that it will put peope off”.

Students: Nose has aromas of white peach, mango, pear, green apple, grapefruit, subtle celery, parsnip, spice and elegant florals. More green apple and stonefruit notes on the fresh, well-balanced palate along with citrus, radish and white florals. Mouthwatering, drying acidity. Nice spice on the finish which is a touch phenolic. Nice texture. Good length.

EDEN HALL 2020 GRUNER VELTLINER
Eden Valley, South Australia
12.4%v/v
RRP$35.00/bottle

Best of tasting: Pale straw in colour with a green hue. Nose has a quite Chardonnay-like framework; aromas of quince, red-skinned apples, grapefruit, root vegetables (including radish, parsnip and celeriac), Bickfords lime cordial and hints of lemon detergent and tinned beans. Great weight, texture, energy, balance and complexity on the palate which features notes of quince, pear, stonefruit and spice. “A very well made wine in a riper style that has been well thought out,” noted one taster, adding the wine was “screaming out for food”. “Riesling feels with a citrus follow up,” noted another taster.

ARTWINE 2021 IN THE GROOVE GRUNER VELTLINER
Adelaide Hills, South Australia
12.5%v/v
RRP$35.00/bottle

Pale straw in colour with a green hue. Simple nose of stonefruit, parsnip, lemon, lime and dough. Soft, approachable and slightly creamy palate which has good fruit weight and acid line throughout. Very varietal. Maybe a touch of resisdual sugar. “In a world where Pinot Gris is so popular this wine won’t offend someone who doesn’t want to see too much savouriness – a nice New World interperation [of Gruner Veltliner] comprising some fruit and creaminess,” noted one taster.

BERRIGAN WINES 2021 SHINING ROCK VINEYARD GRUNER VELTLINER
Adelaide Hills, South Australia
11.5%v/v
RRP$29.95/bottle

Mid straw in colour. Varietal nose of root vegetables, bread, brioche, apple, Bickford's lime juice cordial and a hint of grapefruit and pineapple. A little sluggish on the palate which has good balance, a nice savoury feel and good chalky acid; pear and lemon pith characters apparent with pepper and spice on the finish. "Well made wine but lacks definition," noted one taster.

CHAIN OF PONDS 2021 UNCHAINED GRUNER VELTLINER
Adelaide Hills, South Australia
11.5%v/v
RRP$28.00/bottle

Pale straw in colour with a pale green hue. Sweaty nose upon initial tasting but eventually blew off; vinyl reductive character still apparent. Aromas of celeriac, turnip, light florals and citrus along with some quince and apple. Palate is somewhat closed and muted, possibly due to over-acidification; back palate pinched. Lacking some fruit depth.

HAND CRAFTED BY GEOFF HARDY 2021 GRUNER VELTLINER
Adelaide Hills, South Australia
14.0%v/v
RRP$25.00/bottle

Pale straw in colour with a golden hue. Aromas of stonefruit, peach, quince, parsnip, swede and some tropical fruits. Good energy, acid, palate weight and texture in the mouth. One taster felt the palate lacked varietal characters while another described it as having great varietal expression, noting characters of quince, parsnip, root vegetables and spice; the third taster felt the style was too tight.

HAHNDORF HILL 2021 GRU GRUNER VELTLINER
Adelaide Hills, South Australia
13.0%v/v
RRP$30.00/bottle

Mid straw colour. Vibrant, lifted nose of honeysuckle, tropical fruits, pine lime, banana, custard apple and lemon curd. Palate is lightly-textured and well balanced with a good acid drive. Tropical fruits and lemon flavours on the palate. Some spice on the finish. "An early release style," commented one taster.

EDEN HALL 2021 GRUNER VELTLINER

Eden Valley, South Australia
12.3%v/v
RRP$35.00/bottle

Mid yellow gold in colour. Characters of green bean, gherkin, tinned fruit, grapefruit, turnip and custard apple on the nose which is a touch green. Good varietal characters on the palate which has a good depth of fruit but lacks acid definition on the finish. Nice length and texture. One taster felt the palate was tightly wound and the wine generally was "pushing a Riesling-like minerality".

FORREST 2021 GRUNER VELTLINER

Marlborough, New Zealand
13.5%v/v
RRP$28.00/bottle

Quite bright colour of mid-pale gold with yellow tints. Golden rich hue. Bright starfruit on the nose along with some custard apple, lemond curd, turnip and radish. "Really fun flavours," said one taster. Another taster thought the nose was muted and lacked definition and questioned whether the wine had prematurely aged. Creamy, warming palate with notes of baked apple and a touch of caramel. Good acid, super dry finish. Slight bitterness on the back palate.

Students: Aromas of pears, apples, stonefruit, citrus, honeysuckle, parsnip, green beans, asparagus and a touch of white pepper. Stonefruit, lemon, lime, green apple, lemon curd and raddish notes on the palate along with a hint of florals. Palate is fresh, well balanced and easy to drink. Slightly warming. Nice acid balance. Oily and slightly cheesy finish. Good length.

HAHNDORF HILL 2021 WHITE MISCHIEF GRUNER VELTLINER

12.5%v/v
RRP$25.00/bottle

Bright pale straw in colour. Nose was initially sweaty and had a vinyl like aroma before blowing off to reveal characters of apple, citrus, green beans, lime, some florals and tinned pineapple; almost Sauvignon Blanc-like characters. Green apple, pineapple and orange blossom notes on the palate which has a good acid line and is quite chalky and talcy. "Good line and length for a linear style," noted one taster. "A nice wine that is well put together, well made," added another.

LARK HILL VINEYARD 2021 BIODYNAMIC GRUNER VELTLINER

Canberra District
12.0%v/v
RRP$45.00/bottle

Bright colour of mid yellow gold with a yellow rim. Very lifted floral nose; banana, confected tropical fruits and cheese rind also apparent. One panellist wondered if a small percentage of botryis-infected fruit was used. Soft and creamy palate which has great texture but finishes short and broad. Apparent oak. Lacks an acid line a varietal definition. "A bold oak style," noted one taster.

Students: Red and green apple notes on the nose along with stonefruit, custard apple, celery, parsnip, some quince, white florals, grass, caramel, butter and spice; oak influence apparent. Palate lacks a bit of freshness but has good texture; characters of stonefruit, lemon, lime, turnip, celery and green bean. Smoky/toasty notes also apparent. Bright, zingy acid but slightly unbalanced. Good length. Creamy finish.

QUARTZ REEF 2021 GRUNER VELTLINER

Central Otago, New Zealand
13.5%v/v
RRP$45.00/bottle

Mid gold in colour. Aromas of roasted parsnip, celeriac and coffee grounds along with some mealy, leesy and malo characters which have somewhat dulled the nose. Soft, creamy, forward and complex palate which has good depth and varietal character but is a little broad. Nice chalky acid. "Different, but good diferrent," agreed a couple of tasters. Another thought the wine may have prematurely aged.

SAM MIRANDA OF KING VALLEY 2021 GRUNER VELTLINER

Alpine Valleys, Victoria
12.5%v/v
RRP$30.00/bottle

Brilliant colour of very pale straw with a slight green tint. Lifted and pungent nose featuring aromas of honeysuckle, honey toast, roast parsnip, turnip, green beans, soursob, craft glue and freshly cut sugar cane. One panellist thought the nose was a touch reductive. Complex, soft, lean, rounded and broad palate which has some custard apple characters. Chalky acid. "Lacks varietal character," noted one taster.

Students: Savoury nose of celery/celeriac, green vegetables, lemon, lime, grapefruit, pear, stonefruit, caramel, white florals and soursob. Notes of citrus, red apple, honeysuckle, spices, florals and white pepper on the palate. Fresh, vibrant acidity. A rich, textural style that is complex and well-balanced. Delicate, lingering and slightly warming finish.

STAGE DOOR WINE CO 2021 GRUNER VELTLINER

Eden Valley, South Australia
12.5%v/v
RRP$25.00/bottle

Straw in colour. Quince, stonefruits, parsnip, lemon card, oak creaminess and a hint of tropical fruit characters on the nose along with some leesy, mealy and slight nutty notes. A riper style on the generous palate which has great weight and texture, soft and chalky acid, and a good line; varietal characters perhaps a little muted which could be due to some skin contact. Good phenolics which are in check with the lees characters. "A good worked style," noted one taster. "As a bigger, richer, riper style with good texture, this is probably the best example of the line up," said another.

THE PAWN 2021 GRUNER VELTLINER

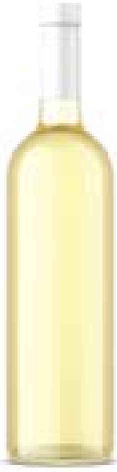
Adelaide Hills, South Australia
12.0%v/v
RRP$26.00/bottle

Extremely pale straw in colour — almost watery — with a green tint. Slightly sweaty nose of ripe pineapple, crushed apple, green/underripe lemon, radish and florals. One taster felt the nose was muted and lacked lift and wondered if the wine had been recently bottled and was therefore experiencing bottleshock. Simple, clean and fresh palate but is a little disjointed and lacks varietal definition; salivating acid although could be better integrated. Lovely spice on the finish. Good length and persistent flavour. Needs time.

Students: Characters of citrus, stonefruits, lime juice/zest, celery, horseradish, asparagus, pepper and white florals on the nose. Palate is clean and crisp with notes of citrus, lemon sherbet, lemon meringue pie, touch of stonefruits, green beans, turnip, spice, and a pleasant brioche character. Vibrant acidity. Some heat on the palate.

WANGOLINA 2021 A-SERIES GRUNER VELTLINER
Mount Benson, South Australia
13.0%v/v
RRP$28.00/bottle

Pale straw in colour. Simple, classic dry white aromas on the nose, along with some sweatiness and wet cardboard. Good energy and depth on the palate which has some residual sugar and lacks varietal definition. Acid a little disjointed.



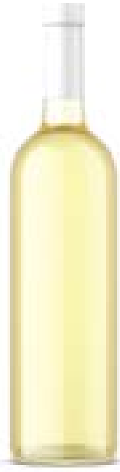
MOUNT BERA 2020 GRUVEE GRUNER VELTLINER (PRE-RELEASE)
Adelaide Hills, South Australia
12.0%v/v
RRP$25.00/bottle

Light green straw in colour. Nose a little closed with characters of custard apple, lemon/lime, some slight nuttiness and herbs and a light kerosene note. Noting leesy, cheesy notes, one taster felt time on lees had reduced the fruit expression in the wine. Palate is balanced and has good depth and varietal characteristics; a touch warm. Nice spicy drive on the finish.

QUARTZ REEF 2020 GRUNER VELTLINER
Central Otago, New Zealand
13.5%v/v
RRP$45.00/bottle

Pale to mid yellow gold in colour with a yellow gold rim. Creamy, developed, lifted nose of caramel, hint of stonefruit and honey and some turnip and root vegetable characters; lactone/icecream sweetness apparent. Textured, creamy and warming palate which has good drive and acid line; lacks fruit and finishes short. Spicy finish. Wood spice to almost clove on the back palate. "I liked some of the Gruner characteristics in this wine – quite varietal and turnipy," said one taster.

Students: Creamy nose with aromas of root vegetables (radish), asparagus, grilled leek, bacon fat, burnt toast, cheese, citrus, florals and vanilla; aged or lees characters apparent; some spice. Palate is generous, textural, has a creamy mouthfeel and is balanced, flavourful with subtle oak adding to the complexity; characters of leek, radish, celeriac, pear, citrus, apple pie spice, vanilla and caramel. Slight residual sugar. Crisp, fresh acidity.



MT BERA 2020 BOUNDLESS HORIZONS GRUNER VELTLINER (PRE-RELEASE)
Adelaide Hills, South Australia
14.0%v/v
RRP$40.00/bottle

Neutral, savoury nose which lacks expression; floral lift of apple blossom and jasmine; touch of lemon and lime, fennel, spice and root vegetables. Light flavours on the palate which is a bit broad. "A cleanly made wine which is spicy and has good weight," noted one taster.

Small-scale dealcoholisation of wine is now possible with Flavourtech's SCC100

Spinning cone column (SCC) technology was developed by Flavourtech almost 40 years ago for the wine industry and has since been the preferred choice for quality wine alcohol adjustment as well as the production of low and zero alcohol wine products.

The SCC's unique thin-film design ensures that raw materials are only exposed to extremely short residence times and low operating temperatures. This results in lower thermal impact compared to other distillation technologies and produces higher quality products that today's discerning consumers prefer.

Until recently, the application of dealcoholisation has been limited to high volume applications, but in response to customer demand, a smaller model has now been developed. The SCC100-W has a throughput of 25-120 litres per hour and has been designed for use in a laboratory, pilot plant or for small production runs. It is manufactured on a compact skid with lockable castors and is quickly assembled, operated and maintained by the user.

The SCC100-W can be used to collect aroma compounds and remove alcohol from wine for the production of:

- low-alcohol wines
- zero-alcohol wines (in conjunction with Flavourtech's resin adsorption column)
- alcohol adjustment to reach the 'sweet-spot' of alcohol concentration.

Flavourtech's SCC100-W has a throughput of 25-120 litres per hour and has been designed for use in a laboratory, pilot plant or for small production runs.

For further information contact Flavourtech Pty Ltd, phone +61 2 6969 1111, e-ail sales@ flavourtech.com or visit www.flavourtech.com

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Electrocoup F3020 — the best gets better

The Electrocoup F3020 has a Bluetooth option which connects the shears to a smartphone app that records pruning data and gives access to pruning shear settings, help and video tutorials.

French company Infaco has released the latest edition of its Electrocoup electronic pruning unit. Significant improvements in ergonomic and technical design mean the unit is 12 percent lighter, 15% more compact and easier to handle than the previous generation. While looking similar to the previous F3015 model, the F3020 features major advancements in technology which make it 20% more powerful and 15% faster. Futuristic battery technology has also led to a smaller and lighter battery.

The F3020 has two modes of operation. The standard mode suits experienced users with blades moving at full speed. Soft mode is similar in speed to the previous model for those operators who prefer that blade speed or are learning to prune. The shears come with three interchangeable heads — small, medium and maxi — to suit the width of the vine or wood being pruned. An optional extension pole allows the shears to be used in tree canopies with ease.

A new Bluetooth option connects the shears to a smartphone app which can record pruning data and allows access to pruning shear settings, service, help and video tutorials.

The F3020 features a new battery, vest and cable designed to significantly improve the ergonomics of the unit. The cable now extends over the shoulder and along the arm, thereby reducing any dangling cables. The separate battery and shear design ensure the hand piece has minimal weight, maximising ergonomics and minimising fatigue. The new battery only weighs 698 grams (down from 950g) and is comfortably worn on the ergonomic harness or is small enough to place in a pocket. One battery will ensure 10 hours of continuous operation, so a full day's work can be achieved without interruption.

Operator safety is important and the Electrocoup F3020 comes with a wireless electronic safety system as standard. This system utilises a conductive trigger so that if the cutting head touches the opposite hand (bare or wearing a glove), the pruning shear blade opens instantly. The unit now features a switch that can turn off the safety system in case the unit is working in wet or damp conditions.

For further information visit www.ryset.com or www.infaco.com