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The Australian Wine
Research Institute

Taking control of alcohol

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Alcohol is the backbone of wine, yet too much can put a wine off-balance. Taking control of alcohol levels in wine is, therefore, critical to the winemaker's art; can winemakers bottle the sunshine flavours we expect of Australian wine but leave out some of the alcohol? One of the keys is wine yeast. Previously chosen for their efficiency in converting sunshine into alcohol, we are now generating new strains of yeast that make reduced levels of alcohol; still lots of sunshine in the bottle but with less risk of 'sunburn'.

Getting the alcohol level right in winemaking can be surprisingly difficult. This is particularly evident when grapes are grown where the weather is warm and fruit is given lots of time on the vine for flavour development; in these conditions 'high alcohol' can become a problem.

Over the past 20 years, the Australian Wine Research Institute has charted an increase in average alcohol levels in Australian wine. In 1984, levels were 12.4% v/v; in 2004, they had risen to 14.2% v/v, and similar stories are heard from around the grapegrowing regions of the world. The 2008 vintage hit another 'sugar high' as the heatwave across southern Australia midway through harvest took its toll.

Hot weather accelerates ripening, which leads to higher levels of sugar. Higher amounts of sugar lead to higher levels of alcohol. In countries like ours, where the sun shines for long hours and some grapes are left on the vine to create rich, full-bodied flavours, high alcohol is becoming an issue.

Wine with high alcohol levels can mean higher costs. In countries where

taxes are levied according to ethanol content, high alcohol wines can be taxed out of the market. High alcohol can also compromise flavour, and today's society is seeking a healthier approach to high alcohol consumption.

To tackle the problem, the Australian wine sector is investigating new ways to lower the concentration of ethanol in wine. One strategy is to harvest grapes before they reach full maturity, when the concentration of sugar in the berries is lower. To a degree, this approach is already being used by some winemakers. But, until we understand viticultural factors that advance flavour development in relation to sugar ripeness, this approach can undermine the full-bodied character and ripe fruit flavours for which some Australian wines are known. Removing sugar from grape must before fermentation is another way to lower ethanol but is relatively expensive to carry out. A third strategy used successfully at a number of wineries around the world is to remove alcohol from wine after fermentation. Even this has its drawbacks: it adds to production costs; might impact wine flavour under

certain conditions, and not all international markets might accept Australian wine that has undergone this procedure.

Another strategy is to target wine yeast. The hunt is on for strains of wine yeast that convert less of the sugar they consume into ethanol (see, for example, Figure 1). Commercially available *Saccharomyces*

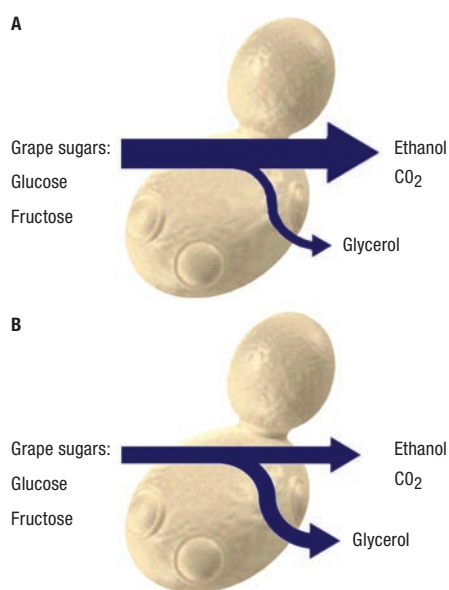


Figure 1. Sugar metabolism of wine yeast. A: Consumption of sugars leads mainly to the production of ethanol and carbon dioxide and, to a lesser extent, glycerol. B: Modifying yeast metabolism so more glycerol is synthesised reduces the amount of ethanol produced.

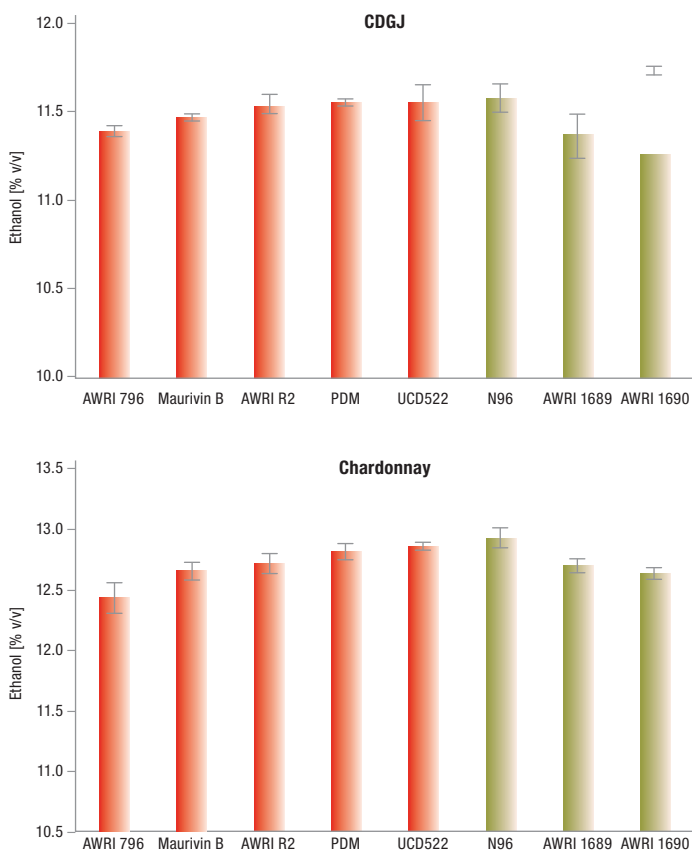


Figure 2. Ethanol content of wine produced from chemically defined grape juice (CDGJ) and Chardonnay juice, fermented with different commercial wine yeast strains.

cerevisiae strains have been categorised by some yeast manufacturers according to the concentrations of ethanol they produce.

But how different are these yeasts? Do strains really differ in terms of the ethanol they produce? To find out, scientists at the AWRI checked how much ethanol is produced by six commercial wine yeasts described by manufacturers as low- or high-ethanol strains.

We also investigated two of our own novel wine yeasts – produced at the AWRI – to see how efficient they were at fermentation and how much ethanol they produced. The two strains came from early stage experimental work at the AWRI aimed at generating yeast that produce reduced amounts of ethanol.

We tested the eight different yeasts using chemically defined grape juice (CDGJ), containing specified levels of sugar and yeast assimilable nitrogen, and Chardonnay juice. Fermentation took place in controlled laboratory conditions and, once complete, samples were collected for analysis. The researchers measured residual sugar, ethanol, glycerol, malic acid and acetic acid as well as alcohol in the synthetic wine (CDGJ) and Chardonnay using advanced analysis techniques.

The concentrations of ethanol produced by the six commercial wine strains are shown in Figure 2. In synthetic wine, ethanol concentrations varied between 11.3% v/v and 11.6% v/v with a maximum difference of 0.3% v/v. In Chardonnay, ethanol content varied between 12.4% v/v and 12.9% v/v, with a maximum difference of 0.5% v/v. The differences look small but are statistically significant. They are also supported by a previous research study that tested 113 strains of wine yeast grown in synthetic grape juice.

Table 1. Product concentrations in wine made from Chardonnay juice using N96 and wine yeast variants obtained by adaptive evolution.

Strain	Ethanol [% v/v]	Glycerol [g/L]	Acetic acid [g/L]	Fermentation efficiency* [g sugar per 1% ethanol]
N96	12.9 ± 0.1	5.8 ± 0.1	0.1 ± 0.0	16.1 ± 0.1
AWRI 1689	12.7 ± 0.1	7.0 ± 0.0	0.1 ± 0.0	16.4 ± 0.1
AWRI 1690	12.6 ± 0.1	7.1 ± 0.0	0.0 ± 0.0	16.5 ± 0.1

* Initial and residual sugar concentrations were used to calculate fermentation efficiency.

Table 2. Product concentrations in wine made from Chardonnay juice using a range of different commercial wine yeast strains.

Strain	Ethanol [% v/v]	Glycerol [g/L]	Acetic acid [g/L]	Fermentation efficiency* [g sugar per 1% ethanol]
AWRI 796	12.4 ± 0.1	7.7 ± 0.2	0.1 ± 0.0	16.8 ± 0.2
Maurivin B	12.7 ± 0.1	6.4 ± 0.0	0.5 ± 0.0	16.5 ± 0.1
AWRI R2	12.7 ± 0.1	6.4 ± 0.0	0.1 ± 0.0	16.4 ± 0.1
PDM	12.8 ± 0.1	5.9 ± 0.1	0.2 ± 0.0	16.3 ± 0.1
UCD 522	12.8 ± 0.0	6.3 ± 0.1	0.1 ± 0.0	16.2 ± 0.0
N96	12.9 ± 0.1	5.8 ± 0.1	0.1 ± 0.0	16.1 ± 0.1

* initial and residual sugar concentrations were used to calculate fermentation efficiency.

SUMMARY

- Hot weather and mature fruit make high alcohol levels in wine more likely.
- The 2008 vintage is set to hit a 'sugar high', with high levels of ethanol.
- Winemakers want to keep alcohol under control for cost, taste and health reasons.
- Scientists at the AWRI have pioneered a new, GM-free approach to 'persuade' yeast to produce less ethanol during fermentation.
- Studies have shown that the maximum variation in ethanol levels from current, commercial yeast strains is 0.5% v/v.
- Innovation at the AWRI is driving the evolution of new, 'low ethanol' yeast in the right direction.

Although there are no published data on final ethanol concentrations in red varieties, our research shows it is very likely that 0.5% v/v is the maximum difference possible by choosing a currently available, commercial wine yeast strain. Commercial strains do not give rise to large differences in ethanol concentrations. As a result, we are trying to generate novel strains of wine yeast that metabolise sugar in such a way that less ethanol is produced while maintaining high wine quality.

Using a non-genetically modified (non-GM) approach, known as adaptive evolution, we are working to create the right conditions to 'persuade' yeast to produce less ethanol. Even though the science is not straightforward, early results have been promising.

So far, two prototype yeast strains have been produced – AWRI 1689 and AWRI 1690. Both generate less ethanol than their parent strain – N96 (similar to strains known in the industry as EC1118, Prisé de Mousse and PDM) – but were still fast at fermentation. The two new strains metabolised a small portion of sugar in such a way that it did not turn into ethanol (Table 1).

It was also important to investigate other metabolites, since major distortions in their concentrations might affect aroma or flavour. Table 2 shows glycerol and acetic acid concentrations in Chardonnay wines, fermented using commercial wine yeast strains. For all strains, there was clearly a link between ethanol and glycerol concentrations. Higher glycerol was associated with lower ethanol. The major component of volatile acidity, acetic acid, was not affected.

The decrease in ethanol concentration might be small compared with the two 'lowered ethanol' prototype yeast strains produced by the AWRI, but we are confident our 'non-GM' strategy is working.

The AWRI's technology should be capable of generating strains that are even lower in ethanol than those currently available. For winemakers wanting to take control of high alcohol, innovation is driving the evolution of wine yeast in the right direction. Nature took some 20 million years to evolve highly efficient fermentation yeast, we hope to reverse some of this evolution in a relative blink of the eye!

ACKNOWLEDGEMENTS

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